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NEW VIEWS OF EVOLUTION

G. P. Conger

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NEW VIEWS OF EVOLUTION

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PREFACE

A brief book on the subject of Evolution needs no long preface; for any one who by means of such a book becomes interested in the subject, the book must itself be only a preface to much wider reading and investigation. Some of the books which would afford material for such wider reading are indicated in references throughout the various chapters. Other books on evolution are mentioned and some of the related philosophical problems are discussed more fully in my text-book, *A Course in Philosophy*.

My acknowledgments are due to several colleagues for criticisms and suggestions; to Messrs. Henry Holt and Company for permission to reprint passages from Bergson's *Creative Evolution;* to Dr. Henry Fairfield Osborn and the American Museum of Natural History, and to the Open Court Publishing Company for permission to reproduce illustrations.

George Perrigo Conger.

The University of Minnesota,
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CONTENTS

CONTENTS

CONTENTS

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CHAPTER I

WHAT EVOLUTION IS NOT

Science By Legislation or By Investigation?

In one of the sovereign states of the American Union, "for the first time in the history of the world the teaching of a scientific theory has been made a statutory offense by direct vote of the people. By a large majority on November 6, 1928, Arkansas adopted an initiated measure (under the initiative and referendum system), carrying with it a fine of $500 and expulsion of any teacher who explains evolutionary theory, and providing a fine of the same amount for a member of any textbook commission who allows the theory of evolution to be taught or to be brought before the students of any public school, any college, or the State University, including the medical school." [1]

The legislatures of Mississippi and, as is well known, of Tennessee have already passed somewhat similar prohibitory laws. In a number of other states where the initiative and referendum system is in vogue, attempts are to be made to persuade the voters to follow the example of Arkansas.

What manner of theory is this, that in an age of sup-

[1] Maynard Shipley, "The Forward March of the Anti-Evolutionists," *Current History*, January, 1929, p. 578.

posed scientific advancement can arouse such opposition? No scientific term is more common, either in newspaper despatches or in the technical books dealing with the various fields of investigation. In recent years there have been a number of books written on one phase or another of the general subject of Evolution; but the conditions of the problem change so rapidly and at the same time need to be studied so inclusively that a book attempting to construct a consistent theory and to present some "new views of evolution" seems to be in place.

When a building is to be erected, often the first thing to do is to clear the site. The clearing of a site usually means cutting down the trees, underbrush, and weeds which have grown up on it, and sometimes means wrecking older buildings which have served their time and must now make way for the new structure. Somewhat similar to this is the task of constructing a clear and consistent account of the theories of evolution. The ground for such a structure is now encumbered by many superficial statements and hastily formed opinions, as well as by some rather well-established older views which should be cleared away. Accordingly we shall begin our attempt to show what evolution is by considering what, at least on the view to be developed in this book, evolution is not.

Evolution and Evolutionism

If we are to be strict and thorough from the very start, it ought to be said first that, contrary to opinions frequently encountered, *evolution is neither a hypothesis, a theory, nor a law; to call it any of these is to confuse it with evolutionism.* We must first consider the distinction between hypothesis, theory, and law, although the

distinction is seldom and perhaps never precise. Generally speaking, it turns on the degree of confidence which is felt with regard to a given statement. If the statement is merely tentative and quite likely to be revised in the light of future developments it may be called a hypothesis; a shorter word for this is "guess", although a hypothesis often has more evidence in its favor than a mere unsupported guess has. A hypothesis which has gained a wider and wider measure of assent may be called a "theory"; a theory is thus a hypothesis which has become strong. The meaning of the term "law" is confusing. First, one must distinguish between the kind of law which is passed by legislatures, and which carries with it the idea of a decree or enactment for the guidance of human action. If the laws of nature are spoken of in this way it is in a religious or theological sense, with some doctrine of God as a Law-giver, rather than in the usual scientific sense of the term. In the sciences a law is a statement of the way in which events are most confidently believed to occur. The confidence of some scientists in some laws is so complete that they speak of the laws as unvarying, "uniform", or "absolute", but as a matter of fact the majority of such views, if not all of them, are open to some possible qualification or exception.

But strictly speaking, evolution is neither a hypothesis, a theory, nor a law. The word "evolution", as we shall use it, is a name for a process or processes which are said to occur in the world. Just what these processes are said to be, and whether or not they actually do occur are problems to be considered throughout this book. The word "evolutionism", as we shall use it, covers descriptions of such processes, whether they occur or not, and

includes whatever hypotheses, theories, or laws are employed in descriptions or speculations concerning them. To put it briefly, evolution is the name for a process, and evolutionism is a name for some statements about that process. In this book, as we shall see, evolutionism is regarded as on the whole stronger than a mere hypothesis, but perhaps not quite to be called a law; we therefore use for it the term "theory". We shall also see later that many statements which are made concerning evolutionism as here defined may also be made concerning evolution, and *vice versa.* The terms are often interchangeable, but sometimes the distinction is important.

Evolution Not Merely Biological

The next point which some readers, as well as some writers, may need to recognize, is that *evolution is not confined to living organisms, and evolutionism is not confined to biology.* There have been a number of reasons why the theory as formulated in biology has been more prominent in the discussions than have theories as formulated in other sciences. Of all the objects studied in the sciences, living organisms, if not actually most numerous, are at least among the most easily observable. They are not merely more familiar than other objects, but they are usually more interesting, since we ourselves are living organisms. Any theory about the world might be expected inevitably to emphasize them; it is not strange, for instance, that they occupy a prominent place in the account of Creation given in the Book of Genesis. Precisely because such comparatively detailed accounts of their origins are given in the Book of Genesis, it is evolutionism in biology, rather than in any other science, which

has come most sharply into conflict with the traditional account and with the various theological doctrines based on it. For all these reasons together, the theories of evolution in biology have on the whole been formulated earlier and more completely than similar theories in other fields, and have received far more of the kind of advertising which theological controversy brings with it.

All such exclusive emphasis upon evolutionism in biology, however, is a superficial view which a very brief acquaintance with the data and literature of the problem is sufficient to destroy. The theory of evolution is encountered not merely in biology, but in practically every other science now studied. If this were not the case, the theory, whatever be its standing in one or another of the sciences, would have little importance for philosophy. The task of philosophy which is important in this connection is that of examining the data of the various sciences, in order if possible to detect principles which are general throughout all of them; and evolutionism for philosophy is a theory of the whole universe rather than of any part of it. In the discussion which follows we shall have to consider evolutionism in physics, chemistry, geology, psychology and sociology, as well as in biology, and it will become plain that the term is not to be confined to any one of these fields.

In avoiding the error of restricting evolutionism to biology, we must be careful not to fall into the opposite error of supposing that every time the term "evolution" or "evolutionism" is used it means a process in all respects similar. The processes in question are, in fact, so different that J. A. Thomson has proposed some distinctions in terminology for the various fields. He suggests

for the development of the solar system the term "genesis"; for changes in which an atom of one chemical element becomes an atom of another element, "transmutation"; for the building up of organic chemical compounds the term "synthesis", and for ontogeny, or the career of an individual living organism of any species, "development". Social evolution he identifies with history or "the human kingdom of ends", and "organic evolution" he applies to phylogeny, the development of species, classes, etc. of organisms.[1]

These proposed distinctions should at least serve as cautions against hasty generalizations, and should make it plain that if, as in our discussion, the term "evolution" is retained in the more general sense it must be only under careful definition.

Evolution Not Straightforward

Once more, *evolution is not to be thought of as a process moving, so to speak, in a straightforward way from simple forms to more and more complex forms, or from "lower" to "higher" forms*; in other words, the process is not in one line, or unilinear, and not in one direction, or unidirectional. When, owing to limited observations, comparatively few living species or comparatively few stars had been examined, it was easy to suppose that the process of evolution had been an advance in one general direction to a result or group of results which could be regarded as marking progress in the given field. But as more and more organisms and more and more stars have been considered it has been found

[1] J. A. Thomson, *The System of Animate Nature,* 1920, Vol. 2, p. 354 ff; *Journal of Philosophical Studies,* 1926, Vol. 1, p. 50.

that if a process of evolution really occurs it must occur along lines which diverge from one another somewhat like the fingers of a hand, as when, for example, according to the evolutionists both birds and mammals develop from a parent reptilian stock. Moreover, the course of evolution is marked by regressions as well as advances; for example, the so-called *Pithecanthropus erectus*, or "Java ape-man", living perhaps 500,000 years ago, walked erect, whereas the men of the Neanderthal race in Europe from 100,000 to 25,000 years ago walked with bent knees and shuffling steps. Where we look for evolution we seem often to find only devolution, or regression. Instances of regression in social evolution are so frequent as to be disheartening. It is a serious question whether one should use the terms "higher" and "lower" in reference to evolution. These terms are taken from our human point of view and our human interests and values, and, although they may be quite satisfactory for us, they may after all give us only a distorted view of the cosmos as a whole. Certainly it is clear enough that even in the social field, where we might perhaps most confidently expect it, evolution is one thing and progress another.

A point of even more difficulty in this connection may be mentioned here and left for clearer treatment later when we come to the actual data of the sciences—namely, that *evolution does not always proceed by what is called integration or creative synthesis, but also by differentiation.* In fact the two processes are very often one process seen from different points of view. We shall return to this point in Chapter II. This point and the others just noted in this section are enough to make the

course of evolution in general remind one of the proverb about the course of true love; it "never runs smooth".

Evolutionists Sometimes Disagree

Again, it must not be supposed that all evolutionists are in agreement on matters of detail. Later on we shall have to consider a number of theories in astronomy, biology, and other sciences, all of which are evolutionistic, but which differ widely in their interpretations of what is taken to have been the evolutionary process. We shall find that the major differences between evolutionists are in their theories respecting the origin of life and the origin of mind. The extreme, or, as Lloyd Morgan calls them, the unrestricted evolutionists hold that life is essentially physico-chemical and needs nothing else for its explanation, while some moderate, or restricted, evolutionists explain the origin and process of life by the aid of a "vital force" which, whatever it is, is at least not physico-chemical. There are similar rival theories as regards the origin and operation of mind. Within the field of biology, again, there are differences of opinion concerning the origin of species, and the criticisms of each theory by the adherents of the others are so severe that some admit, with the eminent English biologist William Bateson, that there is no satisfactory theory, although they go on to say, as Bateson did, that their belief in the theory of evolution is unshaken. We shall see more of Bateson's opinions in Chapter V.

The simple fact is that any one who to-day sets out to study the subject of evolutionism in any other than a superficial way must become accustomed to fragmentary and even conflicting data, to differences of interpretation,

to lack of precise definitions and classifications, and to complicated notions which defy reduction to terms altogether simple. We must remember that no principle of great importance in present-day science is simple. If any one doubts this statement, let him look at the complications recently revealed by the experts in their work on the structures of atoms or on gravitation. But on the other hand we can be encouraged to take as an initial assumption the view that the world, at least in its broad outlines, can be understood if we try to understand it. We shall see that evolutionism, at many points at a loss to account for details of the data, is nevertheless a strong theory when it is understood as applying to the broad outlines of the structures and processes of the universe.

Evidence vs. Inference

As another preliminary point, and at the risk of prematurely touching off one of the chief contentions of our later treatment, it may be said here that, according to our view, *evolution is in the last analysis not a matter of evidence, but a matter of inference.* Everything in this statement hinges upon what is meant by evidence, and it must be admitted that no precise or universally accepted definition of evidence can be given. Defining "data" in the root sense of the word as "things which are given", or are encountered or discovered by us, we would define "evidence" as "data which compel belief". But the fact remains that what compels belief for one person by no means compels it for another, and if any one is disposed to quarrel about it, no definition of evidence and no statement of what constitutes it can be agreed upon. We say, if any one is disposed to quarrel about it; for it is pos-

sible, if any one wishes, to doubt any statement made by another person about the world or to doubt the very existence of that person and that world. There seem however to be some ways of looking at the world and some results of such work which in the long run will hardly be questioned or if they are questioned can be shown to be questioned from motives which themselves are questionable. It is no part of the task of this book to push such theories of knowledge or of evidence or of logic to their extremities. There is enough to talk about within the ranges of data where large measures of agreement are possible.

In the following discussion we shall try to establish the point that the data cited in support of evolutionism do not necessarily *compel* belief, although they unavoidably suggest belief and render easy the inferences which, for us, constitute the decisive steps in the theory of evolution.

By "inference" here is meant a process of reasoning about data, of bridging by hypothesis or theory or law the gaps in the data as presented. Technically, inference may be either "inductive", proceeding from the data to a hypothesis, theory, etc., concerning the data, or "deductive", proceeding, one might say, from one hypothesis or theory to another. In the case of evolutionism the two procedures seem to be combined; the data are enough to suggest the theory, which is strengthened when, as we shall see, it is viewed as a particular example of the general principle of economy of explanation.

It might be added that creationism also is not a matter of evidence so much as of inference. Thus it has long been held, in the so-called "cosmological argument"

for the existence of God, that nature, which is said to be a manufactured product or series of products, requires a Maker. Similarly it has been held, in the "teleological argument", that nature exhibits evidences of purpose or design. But most investigators now agree that these older arguments are at best unconvincing; this means that creationism must rely more upon an inference of the deductive type, based upon the statements of some books or doctrines previously accepted as authoritative.

Evolutionists and Creationists Sometimes Agree

Further, it should be noted that *evolutionism is not necessarily in conflict with some of the teachings of the rival theory or doctrine, creationism.* In so far as creationism is a doctrine of the beginnings of the physical world or of life or of mind, evolutionism may not be opposed to it, for the simple but important reason that evolutionism is not primarily concerned with beginnings, but with outcomes. Creationism usually says that "in the beginning, God created the heaven and the earth", as well as the living organisms. With this view it is quite possible for an evolutionist to agree, holding that God first started a process which now exhibits evolutionary changes. Opposed to such creationism are two views—first, that the universe as it now is may be said to have originated in the operation of some physical cause or causes, such as electromagnetic forces or processes, and not God; and, second, that the universe had no beginning, but is eternal. These two views opposed to creationism may be called naturalism, as contrasted with the supernaturalism which creationism implies. Many evolutionists are naturalists in one or the other of the two

senses noted, but other evolutionists hold some views in common with the creationists. It is quite possible for an extreme evolutionist to say, for example, that God created the world which thereafter has exhibited the processes of extreme evolution; or for a moderate evolutionist to say that God created the first living organism and that thereafter we have processes of biological evolution. In other words, evolutionism is not necessarily opposed to the doctrine of a divine origin of the world, or even to the divine origin of life; but, assuming or having been given certain origins, more or less remote, evolutionism attempts to account for what has happened since.

In this connection, finally, the fact appears that *evolutionism is at most not necessarily opposed to religion, but merely to certain types of theology.* The questions at issue concerning evolutionism, religion and theology cut across one another's fields somewhat as do questions about being a doctor, a Democrat and studying political science might. All of the first three, like all of the last three, may or may not involve one another. Religion, according to the view here taken, is to be understood as a way of living, while theology is a not always complete and not always adequate interpretation of the way of living and of the world in which it is to be followed. Evolutionism offers what is in many respects a variant interpretation of the world, and raises difficulties for some theologies and theologians. But evolutionism in its theory of the world offers a variety of possibilities for the high type of living which deserves the name religious.

CHAPTER II

WHAT EVOLUTION IS

In the preceding chapter, by considering what evolution is not, we have sought to clear the ground for a more positive and constructive statement of what evolution is. In the present chapter, we are to begin the study of this latter problem. The best way to begin seems to be to avoid details for the present and to make first a general statement on broad lines, somewhat as an architect might begin by constructing a miniature model of a projected building. Our general statement will not be so broad that it omits certain qualifications which ought to be observed.

In its most general aspect, then, we should say that evolution is a process which is said to occur in nature. *There seem to be three great fundamental notions essential for all the theories of evolution. We shall mention each of these, together with certain points which need to be observed in its interpretation.*

Evolution a Process of Change

The first notion is that of (1) *process or change in time.* The notion of change is so nearly primary that there is little hope of making it clear by explanations. In fact, the explanations themselves presuppose change and are instances of it.

We may also take for granted here, although the statement may have to be modified later, that change implies time, or is change in time. Without attempting to probe these notions more deeply, let us say that evolution is a particular kind of change in time. It is not, according to our view, every kind of change in time, nor is it necessarily every irreversible change in time. A. J. Lotka defines evolution as "the history of systems undergoing irreversible transformations";[1] while this definition might be adequate in certain respects, it would not, for example, serve to distinguish evolutionism from the opposed theory of creationism, which also accommodates if it does not presuppose irreversible changes, although not of the type studied in mechanics and thermodynamics.

When we attempt to specify the kind of change in time which is called evolution, we begin by studying sequences. This does not mean at all that every sequence demands an evolutionistic interpretation; it means merely that we get at the more specific notion of evolution by studying the more general notion of sequence first. Examples of sequences are familiar enough; thus, there is a sequence in my steps as I walk across the room, or a sequence of cards in the library catalogue. An extended sequence exhibiting some relation between its members may be called a series. Sometimes we observe sequences or series which are easily found in nature; at other times we rearrange materials actually found, placing them or considering them in a sequence or series which is more artificial than natural. If I step across the room, my steps and the nervous reflexes or patterns which they in-

[1] A. J. Lotka, *Elements of Physical Biology,* 1925, p. 24.

volve follow in a certain sequence, or series; there is a first step, a last step, and intermediate steps, and I cannot even if I wish take the last step first. The world around us is such as to forbid such an alteration in the series. But if I consult the library catalogue, the serial arrangement in alphabetical order is somewhat different. While it would not be easy to change such a catalogue, there is no inevitable natural reason why *a* should come before *b*; it is a matter of convenience and long convention, to which the world of nature around us may be said to be indifferent.

Evolutionism Based on Serial Arrangements

Now evolutionism is (2) *an interpretation or suggested explanation for a number of series of atoms, stars, rocks, organisms, traits of character, customs, etc.* One of the chief problems connected with it is whether some of the series thus interpreted do occur in nature or are merely the results of artificial arrangement. In the American Museum of Natural History at New York City there is a famous exhibit of bones of fossil animals from rock formations in the western part of the United States.[1] The exhibit shows skulls, fore feet, hind feet, and teeth of six different sizes, arranged in the order of size with the smallest at the bottom and the largest at the top. The skulls, fore feet, hind feet, and teeth differ in other respects besides size, and these differences are also progressive along the series from smallest to largest. At the left of the bones is a diagram of the strata in which the bones were found, indicating that the smallest bones came from the deepest and presumably

[1] See illustration, p. 115.

oldest beds of rock, while the largest bones came from the later beds. The exhibit is labelled "The Evolution of the Horse", and illustrates the fact that evolutionism is an interpretation of series of data. The evolutionists maintain that such series occur in nature; on the other hand, some creationists may argue that the series of rocks as indicated and of fossils as exhibited are merely artificial arrangements, without any more basis in nature than the *a,b,c* arrangement of the library catalogue. The fossils, according to the opponents of evolutionism, bring no sure indication of the order of their development in time, and, so to speak, cannot defend themselves against whatever arrangement is imposed upon them. And it must be admitted that many evolutionistic arrangements in series which were once supposed to reflect a specified temporal order, for example, in stars, organisms, or societies, have had to be revised in the light of more penetrating investigations.

This suggests that there are a number of cautions to observe with regard to serial arrangements. First we have to remember what was said in Chapter I, to the effect that evolution is not unilinear. We have to do not with one series, but with many divergent, sometimes only imperfectly connected, and sometimes disconnected series. And it must be understood that in our discussion the word "series", unless particularly noted, is used in the plural.

Again, it is important to observe that while very often the observed sequence or the arranged series is one ranging from simple through more complex to the most complex forms, this, as we saw in Chapter I, is not essential. Evolution is sometimes held to proceed from more com-

plex to simple forms. We saw that evolution is not to be thought of as unidirectional, but may be regressive as well as progressive. We saw also that most writers are now agreed that it is better not to speak of a general evolution from "lower" to "higher" forms.

Initiating and Intervening vs. Inherent Causes

But even though it be admitted by every one that certain sequences or serial arrangements in time have actually occurred in nature, this does not carry with it admission of the view most distinctive of evolutionism. Both the evolutionists and their opponents, for instance, admit that trilobites preceded mammals, but the evolutionists and their opponents, the creationists, differ widely as regards the relations of the two. The most essential difference is that *creationism accounts for the members of the series by emphasis upon forces or causes outside the series working in, while evolutionism* (3) *accounts for the later members of the series by emphasis upon forces or causes working inside the series.* In other words, creationism emphasizes the operation of initiating and intervening causes; evolutionism emphasizes the operation of inherent causes. The most familiar example of this difference is in the two theories of the origin of biological species, where creationism maintains that each species, for instance of horse, originates from a separate creative act of God, and evolutionism maintains that the later species are descended from the earlier species by natural processes without supernatural intervention.

We shall see later on that the notions of "force" and "cause", which have just been said to be characteristic both of evolutionism and creationism, may have to be

modified, and that the modifications may result in a weakening of both theories. But the modifications are rather highly technical, and the notions of force and cause have been so prominent in the development of the theories that quite an adequate exposition of them can be phrased in those terms.

It should be noted that the differences between creationism and evolutionism just mentioned are differences of emphasis. We said that creationism emphasizes initiating causes, or an Initiating or First cause, usually said to be God, but evolutionism, properly speaking, is not concerned with initiating causes, and may leave such questions open, confining itself to emphasis upon inherent causes. This makes possible a "reconciliation" between evolutionism and certain theological doctrines, as noted in Chapter I. It should be kept in mind that the two theories do not differ absolutely. Neither can be defined with the last degree of precision; their differences are, again, matters of emphasis. The creationists, for instance, cannot deny the obvious facts of heredity, which would ordinarily be construed as indicating the operation of inherent causes; and neither creationists nor evolutionists can picture their processes as occurring in a vacuum, and overlook the influence of the environment. The environment in its relation to the living organisms may be regarded as an intervening cause or causes, albeit natural rather than supernatural.

"Creative Synthesis"

The question as to how such inherent causes work brings us to an important general principle which belongs at the very core of present day evolutionism. There

seems to be in things which are evolving a tendency to combine with other things of their own kind, and some of these combinations seem to constitute new things, and to mark new steps or levels in evolution. The case of the chemical compound is the most familiar, although not in all respects the best chosen example. Every one knows that hydrogen is a gas and oxygen is a gas; and yet that two atoms of hydrogen and one of oxygen, when brought together under appropriate conditions, constitute a molecule of water. Hydrogen is not wet, nor is oxygen; but somehow water has the new property of wetness. A still more striking example is that of sodium, which is a poison, and chlorine, which is also a poison; but sodium chloride, formed of the two poisons together, is common salt, and is essential for life.

Some other examples are not so clear or so well established, but if they occur are of somewhat more importance for evolutionism. For instance, if electrons and protons exist in the "free" or uncombined state and then by any means combine, that may account for the atom of hydrogen and for the origin of matter; further combinations of hydrogen atoms may account for helium, and combinations of hydrogen and helium may account for the evolution of the heavier elements. A good part of this, at least, seems quite definitely indicated in the data of physics and chemistry. Less definitely indicated, but still plausible, are the steps whereby organic compounds of carbon in the earth by combining with other organic compounds may yield more and more complex compounds, and at length certain combinations of these may not impossibly yield a primitive living unicellular organism. Quite likely unicellular or one-celled organisms,

either by combining or merely by multiplying and failing to separate, as in "colonies", gradually become multicellular organisms. And within some of the individual multicellular organisms, as we shall see, one group of activated cells combined with other groups of activated cells yields at length the type of combination which we call nervous coördination. These examples could be multiplied; but those which have been indicated are enough to show that here we may be on the track of a general principle of great importance.

This general principle is widely recognized in present day thinking but is variously named and interpreted. Herbert Spencer long ago called it "integration"; other names for the process or its results have been "creative resultants" (Wundt); "epigenesis" (Ward); "creative synthesis" (Sellars, Spaulding); "emergence" (S. Alexander, Lloyd Morgan); "holism" (Smuts); and "collective novelty" (R. B. Perry).

We shall deal in the following chapters with a number of detailed points in connection with the process, real or supposed, and its interpretations. The thing to be noted here is that evolutionism is not without a principle whereby the operation of inherent causes can be described; and in proportion as describable inherent causes are detected, there is bound to be less and less demand upon causes regarded as operating from outside. While a "creative synthesis" can never serve to disprove the existence of a "Creator", it tends to make appeal to such a Creator more and more remote.

Two or three remarks may be made here with reference to the principle. In the first place, it is necessary to keep in mind the difference, admitted to be not pre-

cisely definable, between integrations such as we have been considering, and aggregations. An aggregate is in general a looser combination than an integrate; for example a vast number of atoms may be aggregated into a cloud, like a calcium cloud in space; or, atoms even within such a cloud may be integrated into a more definitely structured nebula. In this case it is hard to tell whether a diffuse nebula is an aggregate or integrate. Or, a vast number of unicellular organisms may be merely aggregated, as are the bacteria in the soil; or, some of them may be integrated or synthesized into the higher organization of a multicellular organism. Often one would find it hard to say whether a "colonial organism", such as is found among the polyps, is an aggregate or an integrate. But the very fact that lines between aggregates and integrates cannot be drawn with precision is enough to give the suspicion that there may be processes of continuous transition between them, and processes which the notion of evolutionism is alone adequate to describe.

Processes of Differentiation

Another point of more difficulty should be mentioned here, although it will be somewhat clearer later when we come to the actual data of the sciences. The point is that evolution is in a sense not confined to processes of integration, but may also proceed by differentiation within an integrate. To illustrate the process of evolution, let us take the example of the assembling of a high school in the morning. The students come by ones or twos or threes and gather, let us say, on the steps or the playing field; this represents what we called aggregation. We

will suppose now that the bell rings and the students gather in the assembly room where they are called to order and "school commences"; this represents what we have called integration. But now let us consider the development not of the whole school, but of the history class which meets during the first period in one of the recitation rooms. The history class may be made up of students who, coming one by one from their homes, have missed or cut the morning assembly and gone directly to class. Or, the history class may be made up of a number of the students who have been in assembly and have gone from there to class. The first way of forming the history class illustrates the same principle of integration as that of forming the assembly; but the second way of forming the history class, equally effective, illustrates what we call differentiation. It may be useful to have a term covering both processes; this seems to be afforded by the term "segregation".

Turning from the illustration to the data of the sciences, we may note that a molecule or crystal of salt, for instance, is doubtless not formed by integration of atoms of sodium and chlorine in free space, but is formed by a rearrangement or differentiation of atoms which are already integrated into the astronomical body which we call the earth—or, equally well, are in the earth differentiated within the larger organization of parent sun and planets which we call the solar system. Or, again, a multicellular organism may be regarded as, in primitive cases, an integration of unicellular organisms or, in all later cases, a differentiation, primarily of germinal materials, within the society to which the parent organisms

belong. Thus it appears that things evolve both by integration and differentiation, and in fact that these terms often describe the same process from different points of view. If we start with a relatively simple state of affairs, such as individual students or atoms or unicellular organisms, evolution may be said to proceed by integration to more complex units; but if we start with the more complex units—the high school in morning assembly, or the astronomical body or system, or the society, then evolution may be said to proceed by differentiation. But the results are indistinguishable; it is like saying that the number 4 is at once the square of 2 and the square root of 16. Herbert Spencer called differentiation "secondary integration".

Evolution and "Devolution"

A question often asked concerns the relation between a process of evolution, especially when it is held to exhibit creative syntheses, and another process which is supposed to tend in the opposite direction, and which is sometimes called "devolution". Where evolution is held to involve progress, devolution is associated with degeneration or the opposite of progress; but since, according to our view, evolution is not to be too easily identified with progress, at least some degeneration may be reckoned with evolution rather than with devolution. Properly speaking, devolution should be held to include disintegration, the opposite of integration or creative synthesis. Atoms, for example, disintegrate in radioactivity; organisms decay; nations are scattered; sentiments are disorganized. So many examples can be cited

that there is no doubt that such processes have to be reckoned with in any adequate account of the world. We shall return to some mention of this problem in our final chapter; here it is chiefly of importance to distinguish between disintegration and differentiation. The difference may be seen, in the example of the school, in the difference between dividing the school into the various class groups and dismissing the school, allowing the students to go one by one to their homes; or, in the data, in the difference between the formation of salt molecules of crystals in the earth and the "blowing up" of the earth by the scattering of its atoms or electrons. In general, differentiation promotes evolution, while disintegration, at least for the time being, undoes what evolution has done.

Thus the three notions fundamental and essential for evolution are those of (1) *change in time,* (2) *serial order, and* (3) *inherent causes.* And if the operation of inherent causes is to be described, we must add (4) the general principle of creative synthesis, or, in the widest sense, segregation. These will serve to locate and bound our structure and to determine some of its chief characteristics.

The Main Divisions of An Evolving World

When asked concerning the principal divisions of our structure we find a general answer now available, and an answer which at the very outset may be said to carry with it the impression of a certain massive and grand simplicity. *According to this answer, nature is "naturally" divided into regions known roughly as the physical, the vital, and the mental; or as matter, life, and mind.*

Common experience seems to bear witness to such major divisions of the world, and this witness is confirmed by the divisions and limitations of the sciences. Thus the physical sciences include physics, chemistry, geology, and astronomy; the vital sciences, biology and physiology, and the "mental" sciences psychology, with more or less close connections with neurology, the science which deals with nervous structures. One chief criticism of this mode of division is that it carries no clear recognition of sociology, but this criticism can, as we shall see, be answered in the light of later considerations. We may say then that the theory of evolution is concerned with the development of matter, life, and mind, as these classes of data are studied in the sciences appropriate to them. In what follows we shall for convenience refer to matter, life, and mind each as a "realm".

The difference between restricted and unrestricted evolutionism may now be stated in terms of these realms. The moderate evolutionists maintain that evolution has occurred within each of these realms but not between them—that is, that given the origin of matter, various material structures have evolved one from another; again, given the origin of life, various living organisms have evolved one from another; and once more, given consciousness, or mind, various mental structures or processes have evolved one from another. These restricted evolutionists are, as we said, vitalists in biology and animists in psychology. The unrestricted evolutionists hold that evolution has occurred not merely within the three realms but also between them—so that the living organisms have evolved from chemical compounds in the earth and what we know as mind has then

evolved in the course of the physiological functioning of cells in animal organisms. The unrestricted evolutionists are mechanists in biology and, for the lack of a more precise name, may be called behaviorists in psychology.

CHAPTER III

THE EVOLUTION OF MATTER

We might continue our metaphor of building construction by saying that it is no part of a builder's task to mine the steel or quarry the stone for his structure, or even fully to understand the sources from which these materials are derived. It is sufficient if he knows enough about the materials to use them—that is, if he takes the materials as delivered and gets them into their proper places in the building. Similarly, it is not the task of this book to go into the details of the amazing work of the past few years in experimental and mathematical physics, chemistry, and astronomy; we have only to take over some of the more assured results and proceed to build them into a theory of the evolution of matter such as could not have been foreseen a generation ago.

Nineteenth Century Theories

It will be convenient to start with a glance at the physical sciences as they were commonly construed about the year 1895; every one agrees that since then we have entered a scientific renaissance. In 1895 it was commonly agreed that the atoms of different chemical elements could be arranged in a series according to increasing atomic weights, beginning with hydrogen. The series as thus arranged exhibited periodic properties familiar in

the periodic table, although the variation in periodic properties at one or two places departed from the order of increasing atomic weight. Some early speculations of Prout had pictured all atoms as derived from a primitive form of matter or "protyle", but such views were usually held in abeyance while the atoms were regarded as irreducible one to another and, as far as the empirical evidence went, were held to be the primary units of matter. The very name "atom" by derivation meant "that which is not cut", or divided. Where any theory of their origin was held, it was usually to the effect that the atoms were strains, stresses, or vortices in the all-encompassing æther which transmitted the light of the stars. The fact that strains and stresses could be studied dynamically lent strength to the philosophy of "energetics", which derived all matter from energies, usually energies of the æther.

Atoms were thought to constitute the nebulæ, and it was held in accordance with the nebular hypothesis of Laplace that a nebula of a diameter comparable to that of the present orbit of the planet Neptune in its course around the sun had in cooling and contracting begun to rotate until finally a central mass had thrown off several smaller masses in succession; in this way the sun had given rise to the planets of our solar system. All these masses were at first gaseous, composed of atoms or molecules. Each of the stars passed through well marked stages of cooling; there were white, yellow, and red stars, so named from the light emitted from their outer layers, and the color of the light from a star was an indication of the star's temperature and thus of its relative age.

The planets of the solar system, too, exhibited various stages of cooling; the earth had passed through a long history, with gaseous, liquid, and solid properties, until it had reached its present state with a crust cool enough to support the living organisms.

All this made a rather consistent and on the whole credible theory of evolution, and a theory of evolution which, rather curiously, seems to have gone almost unchallenged by the creationists of the day. So long as the creationists were left free to maintain that there had been an Initiating Cause—"in the beginning, God"—they were not troubled by any inherent causes in which the evolutionists were interested as operative in physics, chemistry, and astronomy. Such inherent causes might be accepted even by the creationists and dismissed as mere secondary causes operating in accordance with the will or purpose of the great Primary Cause, God. As regards astronomical origins, the Book of Genesis taught plainly enough that the sun, moon, and stars were the results of special acts of creation, but there seems to have been comparatively little effort on the part of the creationists to defend their doctrines at this point. The case for "inorganic evolution", to use the words of the title of Lockyer's famous book, went almost by default.

Some of the men of religious interest even found considerable advantage in the doctrine that matter had evolved from energies; this seemed to these men to indicate that the universe at any rate was fundamentally not inert nor dead. Some of the writers went on to find in a dynamic universe constituted of energies a reality which could be called spiritual and even purposive.

The New Scientific Renaissance

About 1895 began the great avalanche of newly discovered scientific data which in more recent years has rendered the nineteenth-century theories of evolution almost unrecognizable. In the last thirty years a number of amazing discoveries and hardly less brilliant inferences based on them have changed the whole face of the physical sciences, and have opened the way for very much more complete and consistent theories of the evolution of matter. All these discoveries are, in a way, interrelated; it will not be necessary to list them in strict chronological order when the important thing for us is to indicate the use to which they can be put in framing an adequate theory.

The avalanche may be said to begin with the discovery of X-rays by the physicist Roentgen at Würzburg, in Bavaria. These rays of very short wave-length at once demonstrated their usefulness for the study of the gross structure of matter; as our understanding of their origin has grown and the technique of their application has been gradually refined, their contribution has been so important that their initial discovery may be said to mark an epoch in physical science.

Changeable Atoms

About the same time came the discovery of radioactivity by Becquerel and the Curies in France; this was enough to show what has since been amply confirmed, that atoms of some of the heaviest elements like uranium are not indestructible, but spontaneously break down by emitting "particles" or rays of three different kinds, called

alpha, beta, and gamma radiations. Alpha radiations have been identified as the nuclei of helium atoms. Beta radiations have been recognized as electrons, or units of negative electricity. Gamma radiations are apparently waves of light of very short wave-lengths, more like X-rays than like visible light. It has been found that a radioactive atom emitting an alpha or a beta radiation changes its structure and constitution and even its place in the periodic table of the elements. Thus uranium, by a long series of alpha and beta changes which cause its disintegration products to trace a zig-zag path along the periodic table, at length breaks down into what may at least for the present be regarded as its end-product, lead. So at least some of the indestructible atoms of the nineteenth century theories have turned out to be destructible, and even by natural processes transmutable into atoms of other elements.

Theories of Atomic Structure

The discovery of radioactivity helped to pave the way for the new electrical theories of the constitution of matter. The best known of the earlier theories was that proposed by J. J. Thomson, to the effect that an atom consisted of a sphere of positive electricity in which were imbedded units of negative electricity, or electrons. But by actually bombarding atoms with alpha radiations from radioactive substances, E. Rutherford showed that, judged from the angle at which some of the alpha radiations were deflected, the positive charges, since called protons, must be concentrated at or near the centers of the atoms. One thus obtains an atom-model or picture which represents each atom as a miniature solar system.

The positive electricity at the center is believed to account for the masses of the atoms, while the electrons of the outer regions are supposed to be the chief factors in determining the valences or combining relations of various chemical elements. The outer electrons tend to form rings, shells, or other arrangements of eight; this accounts for the eight places and the recurring properties shown in the periodic table. The arrangement in eights helps to account for some of the simpler molecules. For example, hydrogen with one outer electron combines with fluorine which has seven outer electrons, thus forming hydrofluoric acid, because the configuration of eight outer electrons is more stable; similarly hydrogen combines with chlorine to form hydrochloric acid.

C. J. Barkla showed that the heavier atoms emitted X-rays having more than one wave-length, and traced these to electrons at different distances from the center of the atoms. H. G. Moseley, a brilliant young English physicist whose death at Gallipoli was one of the greatest losses to science occasioned by the war, showed that atoms of different elements when subjected to bombardment by electrons give different X-ray spectra, and traced the progressive variations in these spectra to progressive variations in the excess of number of protons over electrons in the central regions or nuclei of the atoms. Atoms thus could be arranged in series not merely according to increasing atomic weight, but according to increasing number of excess positive charges in the nucleus, this number being called the atomic number. The latter arrangement, according to atomic number, removes some of the anomalies of the arrangement in the order of weights and is clearer and more consistent. Next, F. W. Aston

of Cambridge, England, showed that atoms assigned to the same place in the periodic table and indistinguishable in chemical properties might nevertheless differ in atomic weights, and that the usual fractional atomic weights assigned to most of the elements were really averages of the weights of large numbers of such differing atoms. To such atoms occupying the same place in the table, often called by the same name, but differing in atomic weights, Aston gave the name "isotopes".

Energy in "Bundles"

Another step of great importance was the formulation by Max Planck of Berlin of the so-called "quantum principle", according to which light is radiated not continuously, but discontinuously, in bundles, or quanta, and the energy and the frequency of radiation are in a certain constant relation. Niels Bohr of Copenhagen was able to apply this theory to the Rutherford atom, and to correlate the results of the theory with the experimental data obtained by study of the spectra of the atom of hydrogen.

All this work taken together leads to the view that the atom of hydrogen is composed of one central proton, which is somewhat like a sun, and one peripheral electron, which may at different instances, be in any one of a number of different "quantum orbits". Sommerfeld, a German physicist, succeeded in modifying the Rutherford-Bohr theory to bring it into accord with the theory of relativity, considered briefly below. Altogether, the Rutherford-Bohr-Sommerfeld theory holds that when an atom absorbs a certain quantum of light there is a discontinuous process, a jump in which the electron disappears from one orbit and reappears in an orbit further

out, although there seem to be certain peculiarities in the dynamics and in the spatial and temporal relations inside an atom which make it impossible to say that the electron passes continuously between the orbits. On the other hand, the emission of radiation in quanta is accompanied by the disappearance of an electron from an outer orbit and the appearance of one in an inner orbit, with consequent shrinking in the atom.

Some questions regarding the Rutherford-Bohr-Sommerfeld, or "solar-system", atom, have in more recent years been raised by W. Heisenberg and M. Born, who maintain that no such miniature solar systems are actually observed and that if one confines himself to actual observations one can have no such definite picture of atomic structures. It is better, according to the Heisenberg-Born theory, to deal only with observed results, all of which occur outside the atoms; the relative positions of electrons within the atoms can then be indicated only in terms of probabilities, expressed by complicated equations of higher mathematics. In spite of this attempt on the one hand to restrict the problem to experimental results and on the other hand to treat it by more general mathematical formulæ, the notion of electronic orbits or of something comparable to them appears to persist.

Origin of Heavier Atoms

Much of the work on atomic structures has concerned the hydrogen atom only; in spite of the fact that it is supposed to consist only of one proton and one electron it is found to be complicated enough to challenge our powers of calculation. A number of writers have supposed that the atom of helium (the rare gas used in dirigibles) is

made up of four atoms of hydrogen; the atomic weight of helium, just under 4, is most easily accounted for by supposing that the four hydrogen atoms when combined do not need as much energy as they do when separated, and therefore radiate a little when making the combination. Actual verification of this plausible hypothesis has been lacking, but R. A. Millikan has detected in the very short "cosmic rays" which continually penetrate the earth from the depths of space some radiations which he has regarded as of the requisite wave-length to correspond to radiations emitted in such a process. His conclusion has not been without question, but most physicists are agreed that helium is probably compounded from hydrogen. Considerations from the relations of atomic weights, from radioactivity, including bombardments of atoms by alpha rays, and from cosmic radiations all unite to indicate that atoms beyond helium in the periodic table are made up of atoms of hydrogen and helium in various combinations.

Thus the way is now clear for a theory of the origin of atoms of hydrogen from electrons and protons, of helium from hydrogen, and of other atoms from hydrogen and helium. It need not be supposed that atoms develop in the order of increasing atomic number—this is doubtless only a serial arrangement, and the development of the atoms is probably not at all unilinear, as, judged by radioactivity, it certainly is not unidirectional.

Molecules and Crystals

We noted that these theories of atomic structure can be correlated fairly well with the requirements of chemical theories of valence and the structure of molecules,

the general features of which are now traced to a "binding" of the outer electrons of the atoms. W. H. Bragg and W. L. Bragg have shown by means of X-rays that crystals are arrangements of atoms, and perhaps sometimes of molecules, in regular lattice-like patterns. This has led some writers to treat molecules and crystals as the structures which in a connected account of physical evolution properly come next after the atoms. It ought, however, to be noted again that molecules are more likely to be products of differentiation of the atoms in a star or planet than to be products of integration or combination of atoms in free space. This is an illustration of the difficult point noted in Chapter II, that evolution may proceed by either of the processes, and that in fact the two processes may be regarded as one process considered from different points of view. Thus from the point of view of the earth, so to speak, the formation of rock salt is a differentiation, a rearrangement among some of the atoms of sodium and chlorine. But from the point of view of the atoms the process is a combination or integration of atoms to form a molecule or crystal. In the case of crystals it is still clearer that the organizations do not occur in free space but are formed by differentiations within the earth.

Crystal structures have been studied exhaustively and with the aid of mathematics reduced to thirty-two types or patterns among which various serial arrangements can be made. The series of crystals suggest series of minerals. There is as yet no complete correlation between the classes of minerals, the order in which they are thought to appear geologically, and the complexity of their crystalline form; but W. H. Emmons has studied

certain primary downward changes in ore deposits in the beginnings of an attempt to indicate serial steps in the process of formation of ores by the intrusion of molten material into the rocks.

The new theories of the structure of atoms have thus helped in the understanding of the rather familiar combinations of atoms in molecules and crystals, and have even thrown some light on the process of evolution of the earth. But the evolutionists, owing to other recent developments, cannot be content to start with the atom. Any account of the evolution of atoms now raises questions concerning the evolution of those constituents of atoms which we called electrons and protons.

The first effect of the discovery of electrons and protons upon the older theories of the atom was to make it appear that atoms could hardly be vortices in the æther; it looked very much, however, as if the electrons or protons, or both, might be such vortices. Presently this view in turn had to encounter the sharp criticism based on the new and widely accepted theory of relativity.

Relativity

The theory of relativity, first sketched by Einstein of Berlin in 1905, although in its beginnings it is hardly ten years later than the discovery of X-rays, marks another great line of advance, perhaps even an epoch in physical science, and the fact that it comes so soon after the X-rays were discovered is one of many indications of the untold rapidity of developments in the past few years. The theory offered an explanation of the result of a famous experiment performed by two American physicists, Michelson and Morley, in an attempt to find differences

in the velocity of light when the earth, at different times of year, was going in different directions on opposite sides of its orbit. The experiment may be better understood by reference to an analogy. Let a swimmer swim a certain distance in a river, upstream and back, and then, with the same velocity through the water, swim the given distance in water which is at rest. He will find that the first swim takes longer than the second. Now the earth in motion through the æther might be compared to the banks of the stream; the æther might be compared to the stream; and a beam of light which is flashed from one point on the earth to a second point at a given distance from the first and then reflected back again might be compared to the swimmer. According to the analogy, it should take more time for the beam to travel back and forth in the earth in uniform motion relatively to the æther than it would if the earth were at rest relatively to the æther, or moving in a different direction relatively to it.[1] But Michelson and Morley could detect no such difference in rays of light flashed in various directions and reflected back to the starting point.

Einstein's way of accounting for the negative result is highly technical and need not be of direct concern for us here. Together with some of its presuppositions it may be stated as follows: All physical science is based on measurements. All measurements involve coincidences in time and space—for example, the measurement of temperature would not be possible without some coincidence like that of the top of a column of mercury with a point on a scale at a certain time. All measurements, more-

[1] See G. D. Birkhoff, *The Origin, Nature, and Influence of Relativity*, 1925, p. 17.

over, are taken with reference to something—in the case of temperature, the scale at the given time—which may be called the "frame" or "system of reference". Measurements must often be taken of moving objects; the motion of an object is expressed by a set of relations between its locations in time and space, the locations being specified in a given frame of reference. For instance, we might describe the motions of a brakeman by saying that he walks southward at the rate of four miles an hour along the top of a stationary freight train which is his frame of reference. But if a given frame of reference is itself in motion, any measurements taken with respect to another frame will not be the same as they would if the first frame were at rest. In our example, the brakeman might continue walking at the same rate as regards the freight train, but if the train started northward and moved at the rate of ten miles per hour, the brakeman would not have the same velocity with reference to an observer standing beside the track. In general, measurements of motion are relative to frames of reference and are modified by motions of different frames.

Now suppose that there are no ultimately stationary frames, but that all observers are in motion relatively to one another. This must be the case, for instance, with observers in the earth as compared to observers in any other similar system of reference. How can there be any uniform measurements, or any uniform scientific statements of the laws of nature? Einstein, in attempting to answer this question, made two assumptions, which are known as the postulates of the special theory of relativity. The first is that the laws of nature are such that

they have the same form for any observer, whatever his velocity be with respect to another observer or frame of reference. The second is that the measurements of space and time by all observers are such that the observers obtain the same value for the velocity of light, whatever be their relative velocities. The assumptions may be stated in another way by saying that by no experiment can we detect any "absolute" motion through space, or motion with respect to an æther. So, on a basis of these assumptions, it was no wonder that Michelson and Morley failed to find what they were looking for.

Does the Physical World Evolve in Æther or Space-time?

All this would not be of direct importance for a theory of the evolution of matter, had it not been for the next step in the argument which a number of investigators, pushing to a position more extreme than Einstein's, presently took. If all observers were in motion relatively to one another in a frame which could be called the totality of spaces and times, or Space-Time, it appeared that this mathematical term might be a sufficient description of the frame, and, since a physical æther could not be detected, it might not be necessary to suppose that there was any æther at all!

The theory of an æther, however, was firmly intrenched in physics. It seemed indispensable so long as light was believed to pass between the stars in waves, because waves seemed to require a physical medium having certain properties to transmit them. Several suggestions were thereupon made with a view to relieving physics of the wave-theory of light and of the æthereal medium along with it. One suggestion was to the effect

that the wave-theory accounted only for resonance effects in matter, *i.e.*, in the earth's atmosphere or in our instruments, rather than for whatever the disturbance is which passes in interstellar or interplanetary space. Other theories began to develop the suggestion that light is not merely a wave-motion or series of waves but is primarily corpuscular, and that a light-wave is a mass or statistical effect, in space and time, of a number of primary disturbances or radiations, *e.g.*, of "light-darts", somewhat as a water wave is a certain distribution, in space and time, of moving drops of water.

The result is that at the present time the question of the existence of an æther is in abeyance. The word is retained by some of the most eminent among the relativists, but for these men the term "æther" is hardly anything more than a synonym for "space" or "space-time". So there is little point in the statement that an electron is a vortex in the æther.

Wave-Theories of Electricity and Matter

Just as the view that the electron is a vortex in the æther began to decline, came a new step with a new view of the nature of the electron. It may not be a vortex in the æther, but the indications multiply that it is some kind of combination of waves or radiations in some kind of space. The theory that electrons are groups of waves has received its most striking development in the work of the German physicist Schroedinger; in connection with it has come a new "wave-mechanics" which finds that matter itself exhibits some of the characteristics, or satisfies some of the equations, of wave-motions. This work is far too complicated and technical for any but special-

ists. Those who are not specialists need to keep in mind that the waves here in question need not be of any form that we could recognize; they are for us more mathematical expressions than physical processes. Nor need the space here in question be our ordinary space. The indications multiply on every hand that our ordinary notion of space is a gross and unanalyzed notion, dominated by our rather gross sensations of sight and touch, and not at all definitive as regards atoms and electrons. But with all the qualifications which have to be made, the fact remains that the view is now more plausible than it has ever been that electrons develop out of energies which when measured in certain ways in certain kinds of space have in general the form of waves.

New Views of Mathematics

Not even here does the analysis of the physicist turned mathematician necessarily stop. He may go on to argue roughly as follows: If physical science depends upon measurements, and measurements depend upon choices of frames of reference, then by suitable choices of frames, measurements can be reduced to zero, and measured quantities and objects can be rendered inaccessible to physical science. If the physical world can thus be reduced to mathematics, why not suppose that the physical world arises out of a system or set of conditions which must be treated primarily not as physical, but as mathematical? This brings us to the amazing theories that the energies which as we said when measured in certain ways constitute waves, are themselves complicated relations between some underlying non-physical structures or frames which have to be studied mathematically, and re-

garded somewhat as the figures in a geometry book or the equations of algebra. Eddington of Cambridge, England, speaks thus of an underlying relation structure.[1] G. N. Lewis, an American physicist, says that "energy itself is now regarded as only a cross section of a greater entity, the tensor".[2] So it begins to be a plausible view that the world we call material "evolved" out of some structures which we may call mathematical, or logical.

Evolution of the Solar System: Chamberlin's Theory

The interests of other scientists in the meantime had been concerned not with such minute or primary structures, but with the more directly evident data of astronomy, and in this ever-fascinating field newer discoveries have been modifying the older theories of evolution. It has turned out that Laplace's nebular hypothesis fails to account for the angular momentum of the sun and planets of the solar system; these bodies appear to have more energy than a cooling and rotating primeval nebula could give them. T. C. Chamberlin of Chicago in seeking for sources of this excess of energy was led to suggest that the planets of the solar system owe their origin to the fact that at some remote period some other star passed relatively near to the sun and by tidal action dragged out successive "planetary knots" from the parent body. These knots then picked up "planetesimals" or small bodies, and organized them progressively into what we know as the earth and the other planets.

[1] A. S. Eddington, *The Mathematical Theory of Relativity*, 1922, p. 224; *The Nature of the Physical World*, 1929, p. 230 ff.
[2] G. N. Lewis, *The Anatomy of Science*, 1926, p. 140.

The Energy of the Stars

Some years before this, proceeding on the view that the solar system was the result of a process of contraction in a nebula once the diameter of the orbit of Neptune, Helmholtz of Berlin had concluded that it must have taken some 20,000,000 years for the sun to shrink to its present size, and hence that the solar system must be of approximately that age. But when the geologists, arguing for example from the rate at which salt is deposited in the ocean, had tried to estimate the age of the earth, they had reached a much higher figure, something like 100,000,000 years. Other calculations based on studies of the length of time it must have taken to form in the rocks minerals regarded as products of radioactivity led to figures even larger, and it became imperative to look for some source or sources of stellar energy other than mere contraction, in order to be able to ascribe to the sun, for instance, an age that would enable it to antedate its planetary offspring.

Such a source has recently been inferred in accordance with the Rutherford-Bohr-Sommerfeld atom and the theories of quanta; these theories taken together have changed our view both of the interior and the exterior constitution of the stars, and have rendered much more complicated the theories of stellar evolution. The newer views are associated chiefly with Jeans and Eddington in England, although the theories of the two astronomers do not agree at all points. The stars are held to be at least at first and in part masses of gas, but of gas composed of atoms. As the stars contract the atoms of the interior are more likely to collide, and to knock off from

one another some of the electrons of their outer rings or regions. An atom which has lost one or more electrons is said to be ionized. The more the star contracts the more of these outer electrons will be knocked off, and the more the atoms will be stripped down to their nuclei. Remembering that according to the work of Moseley the distinctive characteristics of an atom of any element depend upon the excess positive charge of its nucleus, it appears that in the stellar interiors the atoms of any given substance, no matter how many peripheral electrons have been knocked off, are still essentially atoms of that substance so long as the nuclei are intact. The nuclei are very minute, but very heavy in comparison to the outer regions of electrons; hence when the latter are removed the reduced atoms are much smaller and many more of them can be packed into a given volume. There may be alternate stripping and acquiring of electrons. By continued stripping a star may contract until the matter in it is far denser than that in the earth, while at the same time the star may remain a gas; this curious state of affairs is now supposed actually to be illustrated in the small companion of the giant star Sirius.

The process of breaking up of the atoms in the stars appears also to be accompanied by a breaking up even of the electrons and protons, which when certain conditions are right for it are supposed to encounter one another with explosions of prodigious violence, giving rise to radiations of great energy content. Thus it is now supposed that mass itself can be transformed into energy. The interplay of all these structures and processes within a star generates stupendously high temperatures, perhaps in some cases as high as 40,000,000 degrees Centigrade.

The radiations, according to Eddington, are prevented from escaping from the star by an outer region of atoms or molecules which are opaque to most of them. In this outer region radiations are for the most part absorbed by the atoms without loss of any electrons; sometimes, however, an electron is knocked off, the atom becomes ionized, and transmits the disturbance in the form of a radiation travelling outward from the star. But only certain radiations thus selected and sifted pass through the outer regions and, escaping from the stars, register their effects in our eyes, photographic plates, and spectroscopes. The spectrum, or color of light from a star, then, is no simple or direct indication either of its temperature or its age; the star is hotter and much older than the older theories based on such simple data led us to suppose. The light emitted from the outer regions of a star is primarily only an indication of the state of ionization of the atoms of its outer regions, and any arrangement of stars in series designed to point off the process of evolution must be much more complicated. Since they have these vast sources of energy, the stars may be regarded as very much older than the contraction theory allowed, and in proportion as their ages are greater, there are more chances for the type of approach which results in systems of planets. It is thought that there may be at least a few such systems besides ours.

Vast Groups of Stars

With the aid of larger telescopes and improved computations of the motions and distances of the stars, it has been found that perhaps one-third of the stars are binary, or double stars; that many of them near the plane of the

"Milky Way" are aggregated in loose clusters; and that some of them farther from that plane belong in globular clusters which appear to be joining the galaxy. Shapley, the director of the Harvard Observatory, thinks that the Milky Way or galaxy is made up of star clusters.

The newer instruments have made it clear that some of the spiral nebulæ are not masses of atoms like diffuse nebulæ, but masses of stars or of clusters like our own Milky Way. The most conspicuous of these is the Great Nebula of Andromeda, whose light, travelling at the rate of 186,000 miles per second, takes about 1,000,000 years to reach the earth. Such objects as Andromeda and the Magellanic Clouds (visible only in the southern hemisphere) are called "extra-galactic nebulæ", or sometimes "island-universes". Several thousands of them have been discovered.

There are even some indications that some of these nebulæ or galaxies form a "galaxy of galaxies". Some studies have been made at Harvard of such a superorganization of about two hundred and fifty spirals in the northern sky. Hubble has been led to infer that spirals or galaxies are approximately equally distributed throughout a distance of more than 100,000,000 light-years from the earth, but occupying only about one six-hundredth of the "Einstein universe", or universe of curved space conformable to the general theory of relativity.

New Views of Inorganic Evolution

Such are the materials now definitely on the ground for a theory of the evolution of matter. It must not be sup-

posed that all of them are of equal stability; there is always the danger that after a structure is founded on them some of them will have to be replaced. But even if they are taken as indications and suggestions rather than as established facts, their implications are plain enough, and the way is clear for a physical evolutionism which in a first approximation may be pictured as follows:

Some of the radiations in an electromagnetic field which, at any rate for us, conform to equations of wave-motion are grouped or combined into electrons and protons. Some, though not necessarily all of these electrons and protons, are combined into atoms of hydrogen. Some of these atoms of hydrogen are combined into atoms of helium, although this process, according to Eddington may not take place in our kind of space.[1] Some of the atoms of hydrogen and helium are combined into atoms of the heavier elements. The latter combination, if it does not take place in free space, takes place by differentiation after the hydrogen or helium atoms have been but loosely combined in more or less diffuse nebulæ. Within the larger of the less diffuse nebulæ some constituent atoms by differentiation form condensations or knots, and these condensations go through the stages of development characteristic of stars. By splitting or fission double or binary stars are formed, and by tidal action or near approach planetary knots in the case of our sun were, and in cases of other stars perhaps are separated from the parent mass and develop into planets. Meantime either by drawing nearer together or by remaining

[1] A. S. Eddington, *The Internal Constitution of the Stars,* 1926, p. 301.

near together the stars form clusters, the clusters form galaxies, and the galaxies apparently form vast systems of galaxies.

This crude picture raises many points and questions which are encountered in any theory of evolution and which may be considered here in a preliminary way. In the first place, we note that there is an arrangement in series (plural) according to progressive differences in size or complexity or both. Next, it is to be noted that only some, and not all, of the units of any given complexity are combined to form units of the next later kind or level. This point will help us later on to remove one objection to evolutionism as applied to biological species. Again, as we said above, we should note the difference between what we called the formation of a heavy atom or a molecule by a combination of atoms in free space and the formation of a heavy atom or molecule *after* the atoms have been first loosely combined in a diffuse nebula. It is evident that here, so far as the units formed are concerned, practically the same result is reached in different ways, or at least may be studied from different points of view. If we are considering the lighter atoms, the formation of heavier atoms or molecules appears to be a combination, or integration, or creative synthesis; but if we are considering the diffuse nebula as a whole the formation of heavy atoms or molecules within it appears to be a rearrangement of material already belonging to the nebula—in other words, a differentiation. Evolution may proceed not merely by combination of separately existing units, but also by rearrangement of units which have become constituents of larger bodies. Apparently both

processes, integration and differentiation, occur and even converge in closely similar results.

Evolution and Time

This has several very important bearings upon our general problem; one of these begins to appear when we ask whether the sequence, (1) radiations, (2) electrons, protons, (3) atoms, (4) nebulæ—stars—planets, (5) clusters, (6) galaxies, (7) systems of galaxies, is really a sequence in the order of time. This would, in fact, be very difficult to establish; there are practically no observations on a scale adequate to guide us; at their best our observations may be quite fragmentary. In the light of certain general considerations, it seems quite possible that processes of reversal, or disintegration of later members of the sequence into earlier, may occur, so that the physical universe as a whole may always have been as it is now, and that any so-called evolutionary series in time may be merely local—just as the ocean as a whole is always much the same, whatever currents may be swirling about in it at one place or another. And if evolution proceeds not merely by successive combinations of comparatively simple and hitherto "free" units, but also by rearrangements of units already incorporated in more complex units, then it does not matter for the theory of evolution whether the order of increasing size or complexity as indicated is strictly the order of temporal succession or not. The order in time *may* be not as pictured above from radiations to systems of galaxies, but just the reverse, from systems of galaxies to radiations. The stars, for example, may be regarded not merely as combinations of atoms, but as differentiations within a galaxy or clus-

ter, without affecting the general principle of evolution, but only modifying our description of the way evolution proceeds.

Concerning Devolution

Evolution, then, may proceed either by integration or differentiation. Is there any sense in which it may be said to proceed by disintegration? In other words, can the development of the universe be regarded as cyclic, with alternate phases of organization and disorganization, or evolution and devolution? A number of problems are here interwoven, and any adequate answer depends upon extremely technical considerations of what are called the "laws of thermodynamics". These laws are more or less loosely interpreted in current discussions of "conservation of energy". The upshot of the discussions appears to be that no one can be completely certain that the sum total of energy in the universe remains constant; it is possible that the universe is not a closed system and that increments of energy are received or developed in it which are undetectable by any experimental means at our disposal.

The best authorities seem to agree that in the long run energy becomes more and more unavailable for constructive processes such as characterize the course of evolution. Energy, in Eddington's phrase, seems to become more and more "shuffled", and less and less capable of organization. This trend in the universe is summed up in what is called the second law of thermodynamics, or the law of entropy; it is sometimes called "heat death", or "the running down of the universe". Eddington thinks that the probability that this law is true is so stagger-

ingly high that the opposite view is, on the basis of present knowledge, negligible. But for all this it may still be possible for radiations from the stars to collect into matter again before the ultimate running down is accomplished. The prospect of such an ultimate running down does not trouble him. "I would feel more content", he says, "that the universe should accomplish some great scheme of evolution and, having achieved whatever may be achieved, lapse back into chaotic changelessness, than that its purpose should be banalized by continual repetition. I am an Evolutionist, not a Multiplicationist. It seems rather stupid to keep doing the same thing over and over again".[1]

Problems of Evidence

From these remote eventualities we may return to a more immediately pressing question, which is suggested by the reflection that in many cases we have no actual observations of such integrations as are essential for the theory of evolution. It is true that Bohr's theory of spectra is widely enough accepted so that even without observed data we may think of an electron and a proton as combining to form hydrogen; but Eddington's caution, noted above, should keep us from any too hasty assumption about the formation of helium. On the other hand Millikan's interpretation of cosmic rays may be sufficient warrant for supposing that hydrogen atoms are combined into helium; there are other grounds, too, for thinking that hydrogen and helium form the heavy atoms. Again, observation of nebulæ from the diffuse through the planetary types indicates a gradual organization of con-

[1] *The Nature of the Physical World*, 1929, p. 86. See the whole chapter.

stituent atoms, with observable condensations which likely enough are embryonic stars. Beyond this, evidence must give place to inference, and it is obvious that much of evolutionism in the physical world is a matter of inference. It must be admitted that at many points the evidence is weak, and that always the strength of any inference is more or less doubtful.

Problems of Beginnings

The weakness of the whole theory becomes more than ever noticeable for many investigators when the question is asked "What began it?", "What makes the process proceed?", "What makes it all go?" To the question "What began it?" the evolutionist, as we indicated, properly has little or nothing to say. He is not interested in beginnings, and is equally well at home whether the beginning of the process is traced to God, to radiant energies, or almost anything else. His indifference with regard to the question of beginnings may be illustrated by a passage from Jeans in his discussion of "The Physics of the Universe":

"The atoms which are now annihilating themselves to provide the light and heat of the stars clearly cannot have existed as atoms from all time; they must have begun to exist at some time not infinitely remote, and this leads us to contemplate a definite event, or series of events, or continuous process of creation of matter. If we want a naturalistic interpretation of this creation, we may imagine radiant energy of any wave-length less than 1.3×10^{-13} cm. being poured into empty space; such radiation might conceivably crystallize into electrons and protons and finally form atoms. If we want a concrete pic-

ture, we may think of the finger of God agitating the æther. We may avoid this sort of crude imagery by insisting on space, time, and matter being treated together and inseparably as a single system, so that it becomes meaningless to speak of space and time as existing at all before matter existed. . . . Travelling as far back in time as we can brings us not to the creation of the picture but to its edge, and the origin of the picture lies as much outside the picture as the artist is outside his canvas. . . . This brings us very near to those philosophical systems which regard the universe as a thought in the mind of its Creator, and so reduce all discussion of material creation to futility.

"Both these points of view are impregnable, but so also is that of the plain man who, recognizing that it is impossible for the human mind to contemplate the full plan of the universe, decides that his own efforts shall stop this side of the creation of matter." [1]

In contrast to this indifference, the creationist has a definite, authorized, picturesque, and comfortable answer; he says simply that God began the whole process. It might be said that his answer is not so logical as it is theological; he does not attempt to answer the perfectly proper logical question, "What began God?" To the question "What makes it go?" the evolutionist, again, has no such definite, authorized, picturesque, or comfortable answer as the creationist. Where the creationist points to what he considers a Providence as the primary source of whatever energies are required for the maintenance of the world, and holds that this Providence intervenes now and then in the cosmic process, the evolu-

[1] J. H. Jeans, *Nature*, 122, 1928, p. 698.

tionist with his emphasis on inherent causes, looks for "what makes it go" within the system rather than behind or outside it. This force or power which "makes it go" is pictured by some evolutionists as impersonal, by others as quasi-personal and by still others as personal, and identical with the God of theism. But the whole question as to what makes the process go, as well as what began it, may be dismissed as fanciful and unnecessary; it may be said with Laplace that we have no need of such hypotheses, that the observable and most directly inferable fact is that the process *does* go, and that in the interests of economy of explanation, we ought to "let it go at that".

Conclusion

It is our purpose here to indicate rather than to answer these questions as they arise in connection with available data in the physical world. We shall encounter similar questions, without treating them fully, in connection with the data on the evolution of life, of mind, and of society. In the light of the wider assemblage of data encountered in these other fields we shall return to the questions again in Chapter X. In the meantime we may leave the discussion of the evolution of matter by saying that it is not necessarily inconsistent with an initial creationism; that it is considerably strengthened by recognition of the fact that evolution may proceed by differentiation; that it appears to be limited by the probability of ultimate "heat-death"; and that on the whole it is plausible although hardly to be regarded as proved.

CHAPTER IV

THE EVOLUTION OF LIVING ORGANISMS: 1. UNITS OF ORGANIZATION

The Problem of Mechanism and Vitalism

WHEN we pass from questions about the evolution of matter to questions about the evolution of living organisms, we find the evolutionists themselves grouped in opposing camps and encounter one of the major difficulties of the whole subject. This difficulty concerns the origin and often what is supposed to be the nature of the life-process. We noted that the unrestricted or extreme evolutionists hold that life is essentially physical and chemical in its origin; this theory is known as mechanism. The restricted or moderate evolutionists hold that something (it is not always clear just what) other than physical and chemical structures and processes must be invoked to account for the peculiar properties of living organisms; this theory, or group of theories, is often called vitalism.

It is a little difficult to picture these theories in terms of our metaphor of building construction; but we may suppose that after the lower stories representing the evolution of matter are in place, the mechanists, although they, recognizing that the living organisms have much less spatial and temporal range than the astronomical bodies, would likely enough "set back" the stories repre-

senting the evolution of life, still would build these new and higher stories squarely upon the earlier stories. The vitalists would in a way insist upon new and separate foundations—just as sometimes a bank vault in a building or a seismograph in a laboratory rests on foundations of its own, independent of those of the rest of the building. Or it might be said that the vitalists demand expansion joints or perhaps even insulation chambers upon which the stories representing successive stages in the evolution of life may rest.

It must be admitted that a number of eminent biologists have been vitalists. In general, the history of thought shows that other great unifying conceptions besides that of mechanism have had to make their way slowly. And in particular, many gaps in both evidence and inference concerning living organisms have combined to keep large sections of biological data as it were isolated from one another. On any ordinary view the living organisms are conspicuously different from non-living objects around them, and this ordinary view has been stamped with the sanction of the eminent biologists who have maintained that organisms differ from inorganic substances in such properties as irritability, capacity for repair, growth, and reproduction. These differences are held to defy all attempts to reduce life to physics and chemistry. If one makes the attempt, he finds that there are appalling differences of complexity between the known and comparatively simple processes of physics and chemistry and the physiological processes which go on in an organism. Physical and chemical formulæ can be assigned here and there to local processes within the organism, but "the organism as a whole" exhibits an amazing interlocking

of structures and processes which baffles all attempts of the physicist and the chemist to unravel, still more to reconstruct it.

The vitalists also are able to point to some impressive experiments in support of their claims concerning the uniqueness and autonomy of the life process. It has been found that when the growing embryos of various species of animals are interfered with—for example, cut in two—sometimes the remainder of the embryo, instead of growing into a dwarfed organism, grows into an organism of the size and properties characteristic of the species. One of the most striking examples of this is the Ascidian, *Clavelina*; sometimes a full-sized and fully equipped organism can be produced from a fragment left after the heart, stomach, and most of the intestine have been cut away. This has been interpreted, notably by Driesch, to indicate that the developing organism is somehow directed to the production of a full-sized member of the species. Driesch thinks that the organism is directed by some agency not quite conscious or psychical, but a quasi-conscious "psychoid" which he terms an "entelechy". Bergson, noting such facts as that the eye of a mollusk and the eye of a vertebrate are closely similar in function, although mollusk and vertebrate are widely separated in other respects, has held that the living organisms exhibit the working of a vital impulse (*élan vital*), which does for them what mere physical and chemical processes must utterly fail to do.

Synthetic Vitalism, or Organicism

Vitalistic theories like those of Driesch and Bergson are somewhat vague, but it is easy to see that they are

more like the interventionist theories of the older creationism than like any theories which emphasize inherent causes. Bergson and Driesch are of course evolutionists, but their evolutionism is moderate rather than extreme. For various reasons which will concern us as we proceed, the trend of opinion among other scientists has been averse to interventionist theories, and this type of vitalism has seemed too hypothetical and fanciful; but a number of biologists who are sufficiently impressed by the uniqueness of the life-process to call themselves vitalists have traced the uniqueness not to the operation of intervening causes, but to causes operative within the organisms, in the interlocking complexity of processes there exhibited. This type of theory is not interventionist, or, in Broad's phrase "substantial", but may be called "synthetic vitalism", or again in Broad's phrase, "emergent vitalism". Some writers hold that it is better to discard the term "vitalism" here and speak of "organicism". It is hard to distinguish such organicism from mechanism. One might say that in organicism the emphasis is on combinations of elements, or synthesis, whereas in mechanism the emphasis is upon the results of analysis. Mechanism, in other words, is more "reductional". The synthetic vitalist or organismic view is represented by J. S. Haldane and J. A. Thomson. Haldane maintains that in a living organism the actions of the parts are constantly adapted to the changing needs of the whole, which operates as an organic unit. Thomson's view somewhat more closely depicts the actual situation of an organism. He says that mechanical formulæ do not begin to answer the distinctly biological questions. "We need new concepts, such as that of the organism as a historic being, a

genuine agent, a concrete individuality which has traded with time and has enregistered within itself past experiences and experiments and has its conative bow bent toward the future".[1] It is obvious that this synthetic vitalism or organicism is more in line with the general trends of evolutionary theories. If the difference between living and non-living is one of complexity and intricacy of interactions, it is conceivable that it can be accounted for in terms of inherent causes; but in order to see whether this is so, the processes of organisms must be subjected to analysis, and whatever possibilities there are of reconstruction of the organisms and their processes out of the products of analysis have to be considered. Such work as this leads to the mechanistic theories.

Arguments of the Mechanists

The mechanistic biologists point first to the fact that no case is certainly known in which organisms fail to conform to the laws of physics and chemistry. There are still some unsolved problems here, and there is room for debate, particularly as to whether organisms exhibit conservation of energy. For instance, oxygen is passed through a certain membrane in the human lung at a pressure higher than that at which it is received into the body from the outer air; and there is always the possibility that this means that an increment of energy is supplied from a non-physical source. But on the other hand it may be argued that the source of this energy is to be looked for merely in other portions of the organism which, as a whole, conforms to the law of conservation of

[1] J. A. Thomson, "Life and Death," in J. Hastings, editor, *Encyclopædia of Religion and Ethics,* Vol. VIII, p. 8.

energy at least as well as any other physical system does. So the organicist may supply an answer which the mechanist lacks, but the mechanist may interpret it in his own way.

The mechanist's answer to the arguments based on experimental interference with growing embryos and organisms is, as might be expected, more complicated; no mechanist need maintain that life with its various interlocking processes is capable of any simple explanation. In order to account for processes of organic regulation and replacement such as the experiments indicate, the mechanists hold that an organism in developing by successive cleavages of the fertilized egg exhibits successive embryonic levels, each of which exercises (perhaps by means of hormones transmitted in the blood) certain specific effects upon the organism up to that point and conditions any further developments. It is the function of the earlier levels to give rise to later. Now if the earlier levels have at a given time given rise to later levels and the latter are in their normal positions, then the earlier are inhibited from producing any more of the later levels; but the removal of the later levels removes the inhibition, with the result that replacements appear.

The mechanists have also developed some arguments designed to break down from the other direction the insulation between matter and life. They hold not only that the organisms conform to the laws of physics and chemistry but also that various inorganic substances exhibit at least the rudiments of properties which the vitalists hold to be restricted to living matter. Here again there is room for differences of opinion, and much depends upon precise definitions of terms. But the mecha-

nists, if granted definitions of suitable breadth, can argue for instance that a photoelectric cell exhibits irritability; a crystal exhibits processes of repair; a liquid crystal exhibits growth by intussusception—*i.e.*, by taking new materials into its interior and assimilating them to the structures already present; and an oil drop under certain conditions divides by fission into two drops.

The mechanists are particularly at home in arguments based upon analyses of living cells into their constituent parts. Cells are composed of protoplasm, which is a general term for simple living matter; protoplasm under suitable reagents can be made to yield proteins; proteins can be broken up into peptones, polypeptids, and amino acids, and amino acids can be analyzed into compounds of nitrogen and compounds of carbon. These successive analyses are said by the mechanists to reduce living organisms to chemical compounds and to make easy the presumption that the original living organisms were built up of such substances.

The Problem of Artificial Creation of Life

The attempt to retrace these steps and to synthesize even the simplest living organisms out of inorganic compounds is often talked about, but the gap between inorganic and living is so enormous that all attempts to bridge it thus far have fallen far short of success. From time to time there are newspaper reports of such an epochal achievement, but all such reports up to date have turned out to be unfounded. The vitalists have not been slow in pointing to these failures as indications that living organisms cannot be artificially synthesized, and that "life can come only from life".

But the mechanists are in position to urge some special conditions and "extenuating circumstances" to account for their failures. Life, they say, appeared in the earth in primeval times—perhaps a billion years ago—when natural conditions were quite different from what they are now. For one thing, it seems likely that at that remote period the sun was radiating energies of a different wave-length, not now available in sufficient quantities either in nature or the laboratory. Probably, too, the rocks near the surface of the earth contained radioactive minerals in a different state, also capable of furnishing energies which cannot now be duplicated. Atmospheric conditions and the chemicals carried in solution in the oceans are also thought to have been different in primeval times. Hence any present attempts at synthesis are under formidable natural handicaps.

In spite of these handicaps some experimental results have been obtained, which, even though they are only partial and fragmentary, are to the mechanists very notable indications of processes which once took place, or which perhaps even now are taking place in nature. These results are found, first, in artificial imitations of organisms; second, in recent work on crystals, colloids and the relations between them; and third, in the actual syntheses of organic compounds which belong part way up in the scale of increasing complexity of organization which leads to the complexity of the living organisms.

Stepping-Stones Across the Gulf

It should be made clear that by the phrase "production of imitations of living organisms" it is not meant that any products of laboratory synthesis can even by

stretching the term be called "living"; they are not living organisms, but exhibit one or another or a few of the properties of living organisms. In the work on such imitations a prominent part has been played by S. LeDuc, who has furnished striking imitations of growing plants by certain crystalline preparations. Rhumbler also showed that a unicellular organism could be imitated by a colloidal product which he called an "artificial amoeba".

Recent work on crystals and colloids and their relations has on the whole tended to diminish the sharp contrast between the inorganic and the organic; the distinction between crystalloidal and colloidal substances seems to be based on the facts that the former pass through certain membranes while the latter do not, and that the latter, being larger and more complex organizations, come to exhibit important surface properties. There are inorganic and organic crystals, as well as inorganic and organic colloids. It has often been asserted that crystals are different from cells because while masses of crystals do grow, it is only by adding successive crystals to the outside face of the mass, whereas cells grow by "intussusception". But O. Lehmann has shown that a type of organization like that of crystals may occur not merely in solids but in liquids, and he maintains that liquid crystals do grow by intussusception.

Many studies of the interactions and structures of cells have converged upon the view that these are best explained in accordance with the principles of colloid action. Food materials, for example, appear to diffuse gradually into a cell as if through successive membranes and a cell thus seems to be divided into a number of chambers or "cell-phases"; it is, in effect, a colloidal system.

Proteins, too, the principal building stones in the chemical architecture of cells, under certain conditions exhibit the physical properties of colloids.

So far as actual laboratory synthesis goes, it is quite true that the gap between inorganic and organic has not been bridged, but the striking thing is that on a basis of recent experimental work it is now possible to indicate a series of organic compounds of increasing complexity which, if they do not serve as a bridge over the gap, may serve as so many isolated but successive stepping-stones to enable the extreme evolutionist theories to get across. In the first place it has been shown that carbon dioxide and water, in the presence of colloidal ferrous hydrate, combine in sunlight into formaldehyde; the carbon dioxide was perhaps available in primeval times, derived from the rocks by way of the air. Baly, Heilbron, and Hudson have shown that formaldehyde, under the influence of ultraviolet rays, may be made to link to potassium nitrite (formed from the nitrogen of the atmosphere) to yield formhydroxamic acid compounds of the type HO-CH-NOK. These compounds, in turn, may react with activated formaldehyde to give complex nitrogen-containing compounds, some of which are of alkaloidal nature, but others of which have the characteristics of amino acids.[1] In Fischer's classical achievement in 1907, eighteen amino acids were synthesized into a polypeptid of which the molecular weight, *i.e.*, the sum of the atomic weights of the constituents, amounted to 1213.

Somewhere beyond the polypeptids in degree of complexity belong the proteins. It is now quite possible to argue that the type protein is understood and has even

[1] N. Paton, "Vitalism," *Scientia,* Vol. 37, 1925, p. 98.

been synthesized, although many details remain to be filled in and rendered precise before the synthesis is complete. Judged from the results of analysis, it appears that a protein base and nucleic acid (another complex organic compound) together make up nuclein, which by some is identified with chromatin, one of the most distinctive constituents of the living cell. The British cytologist Minchin maintained that chromatin granules in a cell are the present representatives of primitive free-living organisms, or biococci, which antedated our present unicellular organisms and were their evolutionary ancestors. Somewhat similar theories of infracellular organisms have been held by a number of other eminent workers in this field. Some have urged that present-day "filter-passers", such as the exceedingly small organisms which cause some diseases, are to be classed as infracellular. The best known examples of unicellular organisms are bacteria and amoebæ.

It must be admitted that to minds accustomed to evolutionist arguments which always pass from arrangements of data in sequences or series to inferences concerning inherent causes, these mechanistic stepping stones between matter and life are quite impressive.

Vitalist Objections

A few years ago the vitalists were able to make quite an effective rejoinder, based on Helmholtz's calculations, mentioned in our preceding chapter, that the age of the solar system was of the order of 20,000,000 years, and that the earth and all which it contains could have had only this period of time in which to evolve. And if, as the mechanists maintained, the evolution of the living

organisms were merely the result of undirected chance, no such results as those actually observed could possibly have been produced in such a "short" time. More recently, however, owing to the disclosure of vast sources of subatomic energy, it has been found that any star may radiate for millions of years without appreciable shrinkage in diameter, so that the solar system is doubtless vastly older than Helmholtz supposed and the force of this vitalist argument is as good as spent.

The vitalists are still able to urge that much of the mechanist argument about chemical synthesis is inference rather than evidence, and that even the simplest living organism is of such unheard-of complexity that any attempt to assign chemical formulæ for it is absurd. The complexity is not merely unheard-of; it is almost inconceivable. It may be worth while in this connection to reproduce Fischer's formula for his polypeptid, of 18 amino acids. It runs $NH_2 . CH (C_4 H_9) . CO [NH . CH_2 . CO]_3 . NH . CH (C_4 H_9) . CO [NH . CH_2 . CO]_3 . NH . CH (C_4 H_9) . CO [NH . CH_2 . CO]_8 . NH . CH_2 . CO_2 H$. It has been calculated that there are 816 different ways of arranging these atoms in order to yield this same chemical product. And this polypeptid is only a step on the way to a protein; to the complex protein hæmoglobin the formula $C_{600} H_{960} N_{154} Fe O_{179}$ has been assigned, and a protein is only a step on the way to a cell. A single liver cell is said to contain some three quintillion molecules. The adult human body contains practically sixty trillion cells—enough so that if each of these cells were represented by a letter in the thirteenth edition of the *Encyclopædia Britannica*, printed on thick paper, one adult human body would be represented by a library about

as large as the Congressional Library at Washington which would contain *Britannicas* and nothing else.

It is clear from all this that if the synthesis of living organisms is a problem of proceeding among all these possible combinations until one unique combination or a few combinations which may be called living are hit upon, the problem may as well be given up; the proverbial finding of the needle in the haystack would be easy in comparison. But the mechanists can point to the undoubted fact that all living organisms are labile and fluctuate within wide limits, while still maintaining among their constituents the balance and mutual interaction which, according to mechanists and synthetic vitalists alike, is what we know as life. Most likely the problem of synthesis is not to find one combination, but *any* one of a very large number which satisfy the conditions. Even at that, the problem bristles with so many difficulties that some biologists disregard it altogether, convinced that attempts in that direction must be fruitless. But the mechanists point out that to disregard a problem is not to solve it.

Speculations About the Origin of Life

Speculative theories of the origin of life have been innumerable; of them we shall mention only a few of those elaborated in recent years. Some of the most notable have been presented in addresses at the British Association for the Advancement of Science, and may be found in the *Reports* for the various years. Thus Tyndall in the famous "Belfast Address" of 1874, declared "Believing, as I do, in the continuity of Nature, I cannot stop abruptly where our microscopes cease to be of use. Here the vision of the mind authoritatively supplements the

vision of the eye. By an intellectual necessity I cross the boundary of the experimental evidence, and discern in that Matter which we, in our ignorance of its latent powers, and notwithstanding our professed reverence for its Creator, have hitherto covered with opprobrium, the promise and potency of all terrestrial life".

In 1912 at Dundee, E. A. Schaefer maintained that the general results of scientific investigations tend to show that living beings are governed by laws identical with those which govern inanimate matter, and that we are compelled to believe that living matter must have owed its origin to causes similar in character to those which have been instrumental in producing all other forms of matter in the universe—in other words, to a process of gradual evolution, a gradual process of change from material which was lifeless, through material on the borderland between inanimate and animate, to material which has all the characteristics to which we attach the term "life". But, he went on to say, if living matter first in the form of a simple slimy colloid has been evolved from lifeless in the past, we are justified in accepting the conclusion that its evolution is possible in the present and in the future, although we have no direct evidence of such evolution, and might not be able to detect the data for it even if it were before us.

In 1922 at Hull, E. J. Allen in an address on "The Progression of Life in the Sea" held that, as we have noted above, recent progress in chemistry, showing that carbon dioxide and water under the influence of light can be made to form formaldehyde, which polymerizes into sugar and also combines with nitrites to form nitrogenous organic substances, goes far towards bridging the gap

that has separated the inorganic from the organic. He supposed that as the molecules grew more complex they for purely physical reasons assumed the colloid state. The colloid state would mean among other things, an electrically charged surface, with attraction of surrounding ions. Now during the day with its available daylight, there would be plenty of external energy to assist such processes, but the light is cut off at night. When the light is cut off, the colloid or compound begins to furnish energy for fresh changes from its own internal stores—in other words, it becomes "autotrophic", or self-nourishing, and thus crosses the line between the non-living and the living.

In America, for example, L. T. Troland has traced the origin of life to the action of enzymes. Enzymes are, presumably, chemical substances which are "catalysts" and as such have the power to hasten other chemical reactions and to assist in the production of specific chemical substances. Troland thinks that such an enzyme may have come into contact with oily material in the primitive sea water, hastened its formation, become enveloped in the products of such a process, and aided in the formation of other combinations of the same kind—all of which amounts to the formation and reproduction of primitive organisms.[1]

The leading mechanistic biologist in America has been Jacques Loeb. Although an avowed mechanist he seems to have advanced no hypothesis as to just how living organisms first originated. He felt that there was a pronounced gap in our knowledge of the precise chemical character of the enzymes or catalyzers, but that nothing

[1] L. T. Troland, "The Chemical Origin and Regulation of Life," *Monist,* January, 1914, p. 10 ff.

as yet indicated that the artificial production of living matter is beyond the possibilities of science.[1]

Evolution of Higher Organisms

The mechanistic theories thus far studied, even if accepted, would provide only for the evolution of infracellular and unicellular organisms, whereas all our most familiar organisms are multicellular. The evolutionists, however, have no hesitation in claiming that primitive unicellular organisms by clinging together, sometimes merely by failing to separate completely after reproduction, give rise to masses or colonies in which owing to differences of position of the cells there is division of labor, with something of the differentiation of structure and specialization of function which marks the multicellular organization. The distinction between colonial organisms and multicellular organisms cannot be drawn with precision. That the latter are primarily traceable to unicellular units is inferred from the fact that when a sponge is passed through a filter in such a way as to split the sponge up into single constituent cells, the cells thus split up reassemble on the other side of the filter. It is of course true that the multicellular organisms which we know best, including our bodies, are not formed by such syntheses of one-celled organisms, and it is plain that some other principle or process must be found to account for them. The process of differentiation, above referred to, seems to be precisely what is needed here; this is another example of its great usefulness for evolutionary theories. Multicellular organisms occur not merely as syntheses from one-celled organisms;

[1] J. Loeb, *The Mechanistic Conception of Life*, 1912, p. 5.

they occur as differentiations or rearrangements of material within a society. The material is primarily germinal material, but it is augmented by whatever materials the growing organisms ingest as food. The problem of the evolution of different species of biological organisms will be discussed in the next chapter.

The Problem of the Evolution of Societies

One of the most debated questions concerning the evolution of life concerns the place in such evolution to be assigned to social organizations, particularly to human societies. It is certainly for the evolutionist an attractive possibility that certain inorganic compounds unite to form certain organic compounds, that organic compounds, perhaps in more than one step, unite to form infracellular and unicellular organisms, that some of these in turn form multicellular organisms, and that certain multicellular organisms by their combinations form societies.

Against this view some apparently strong objections have been urged. In the first place, it is said that the other combinations mentioned have been marked by contiguity of their parts, whereas in a society the constituent organisms are discrete from one another. But it may well be replied that contiguity of parts is not essential, and moreover that in accordance with present knowledge of molecular and atomic structures no case of contiguity is all that it seems to be. X-rays for example, penetrate readily enough between most of the constituent atoms of a cell or the cells of an organism. Perhaps when all conditions are considered the organisms of many societies, even if capable of locomotion, are relatively to their sizes and distances not farther apart than are the mole-

cules of a cell, although of course the constituent cells of an organism are relatively closer together.

A more serious objection comes from the history of sociology. Historically there have been three great theories of the relations of individual and society, and the two theories which seem most favorable to the principle of synthesis have been generally dismissed as inadequate. The first is the "contract theory", made most familiar to western thought by Thomas Hobbes and Jean Jacques Rousseau; according to this view a society may be said to be formed like a primitive town-meeting, by men who previously living as individuals "in a state of nature" organize in the new way for mutual security and advantage. Biological studies soon made it plain however that this could not be the whole story. The very process of multicellular reproduction shows the individual organism to be a product of two parents who are thus already members of a society. And the fact that such organisms were found to be composed of cells each of which theoretically is a living organism made it easy to suppose that a society is an organism of a higher order, of which ordinary multicellular organisms constitute the "cells". Thus arose the organic or organismic theory of society, to supplement or even to supplant the contract theory. The organismic theories were in full tide about the year 1900; they fell into disrepute partly because they were worked too hard. Their adherents tried to find too many analogies between the organs, functions, and even the diseases of a multicellular organism and what were held to be corresponding structures and processes in a society. Another reason for the decline of the organismic theories was that in an organism no adequate analogy was pro-

vided for the work which individual minds accomplish in social organization; the organismic theories neglected the psychological and mental factors. Hence arose the third, or psychological theory of society, which regards society as essentially the product of minds. The third theory, like its predecessors, appears to have had its time when almost exclusive emphasis was laid upon it, but it is now becoming clear that even though society in all its recognizable forms is moulded by minds, there must be an underlying biological structure or no amount of moulding would produce the forms which we see.

That a society may be fairly described as a superorganism appears perhaps most clearly in the study of insect societies, with their high specialization of functions among various castes and individuals. Of recent writers W. M. Wheeler has been prominent in the advocacy of this view. In his *Emergent Evolution and the Development of Societies* he says that such non-human societies are superorganisms, in which the constituent multicellular organisms function as interacting determining parts. No less than thirty independent cases of this have been traced among the insects. There are various degrees of integration of such superorganisms, marked by predatism, parasitism, symbiosis, etc. By combinations of colonies of insects, super-superorganisms are formed, and human societies above the level of the horde are essentially such super-superorganisms, although they have developed innumerable interrelated groups and associations. Most insect societies grow to an adult stage like an organism, but human society now grows by a kind of interstitial swarming, except in processes of colonization. Wheeler has not been principally concerned with human societies;

the impression prevails among many investigators of the latter that any application of such ideas to human societies still seems to savor too much of the older organismic, if not the contract theories. But it seems to be agreed by all that organismic theories of society are admissible so long as they refer to general principles of organization observable in an organism, without carrying with them the necessity of finding analogies for such organismic features as noses or heart disease.

Perhaps what is needed here in order to make it clear that the evolution of life can extend to social units is another application of the general principle that evolution can proceed by differentiation as well as integration. We shall try to show later that if this is the case, the agency of mind in what would otherwise be a purely biological group may constitute an example of the general principle, so that psychological theories of society as well as organismic theories may be united in evolutionism.

If this is the case it should be possible to account for various units of human social organization as successive combinations of increasing degrees of complexity. It is most natural to think of single individuals as combining in families or hordes, of families or hordes as combining into tribes, of tribes into nations, of nations into federated states, and of federated states into the great continental, racial, and interracial groups such as constitute the world-society.

It should be noted that with the increasing domination of man over the other species of plants and animals, particularly evident in processes of domestication, the story of these human groupings comes more and more to be that of the other species as well. No tribe or nation

exists in a vacuum; there is always an environment, with the plants and animals which are peculiarly appropriate to the given human organization.

Conclusion

In general, it appears proper to say that the indications multiply that an orderly series of stages or levels can be indicated, all the way from simple organic compounds to the most inclusive social organizations. The case for organicism and even for the mechanistic theories, and thus at all events for extreme evolutionism, is correspondingly strengthened, although it is not yet possible to argue for any of these altogether on evidence which is not supplemented by inference.

CHAPTER V

THE EVOLUTION OF LIVING ORGANISMS

(*Continued*)

II. THE ORIGIN OF SPECIES

IT is apparent by this time that the problems of evolution are much broader than that of the origin of biological species, but since it is this special problem which has served to concentrate attention upon evolutionism and has borne the brunt of the anti-evolutionist controversy, any treatment of the general subject must consider the special problem in some detail.

Classifications in Biology

When one surveys the vast array of plants and animals, one is of course aware of certain broad general resemblances but also of marked differences between them. These facts of resemblances and differences are summed up in the classifications employed by biologists; the particular branch of biology which is concerned with classifications is called taxonomy. The classifications are very elaborate, and the divisions and the terminology used to indicate them vary considerably with various authors and with different kinds of plants and animals. For example, it may be said that the plant and animal kingdoms are each divided into phyla, and the phyla into

classes. Then follow, as successive subdivisions, orders, tribes, families, genera, species, varieties (sometimes sub-varieties, races, sub-races), and individuals. The crucial problem of evolutionism here is that of the origin of species. The evolutionists contend that one species arises from another in the course of ordinary reproduction. In the evolutionist arguments serial arrangements in the order of complexity and interpretations in terms of inherent causes appear in their most conspicuous forms.

Evolutionism Not a New View

In recent years it has become common knowledge that the view of evolutionism is very old, virtually being found, for instance, in ancient Greek philosophy. Anaximander of Miletus about 600 B.C. held that man had come from the fish. Aristotle, according to Newman,[1] had substantially the modern conception of the evolution of all later life from a primordial soft mass of living matter. He had an idea, too, of a series of species or forms, beginning with plants, then animals like sponges, then animals with sensibility and the power of locomotion, then animals of various higher grades, with the series culminating in man. He perceived the unity of type in certain groups of animals, and thought that rudimentary or vestigial organs were tokens whereby Nature sustained such unity. And when one looks through his work one finds that he may be said to have believed in what we now call the inheritance of acquired characters.

In the Middle Ages the great Church Father Augustine (353-430) combined the doctrine of the Book of Genesis with some of the teachings of Aristotle, holding

[1] Quoted by R. S. Lull, *The Ways of Life,* 1925, p. 317.

the doctrine of Creation, with God as the Primary Cause, but maintaining that thereafter there had been gradual development, in the course of which potentialities implanted by the Creator became actual. The world, one might say, was thus traceable to the combined action of supernatural and natural causes. Thomas Aquinas (1225-1274), the greatest of the systematic theologians of the mediæval Church, was content virtually to follow Augustine at this point. His famous doctrine that the truths of nature were obtained by the use of reason, mainly as Aristotle had used it, while at the same time supernatural truths were received by revelation through the Bible and the Church, made it possible for many later thinkers to reconcile evolutionism and creationism, as well as other questions at issue between certain sections of science and certain kinds of religion.

Some of the early modern philosophers in their crudely empirical or frankly speculative studies of the world hit upon facts and employed ideas which were destined to be of much use in the later working out of the theories of evolution. Thus, according to Osborn, Francis Bacon (1561-1626) pointed out the evidence for variation in animals and plants, and the bearing of this upon the production of new species and upon the gradations of life. Leibnitz (1646-1716) was of service in showing that a theory of the evolution of life was a necessary part of any large general theory of the universe, and in giving examples of gradation of character between living and extinct forms, as proof of the universal gradation or connection between species.[1]

[1] H. F. Osborn, *From the Greeks to Darwin,* 1913, p. 88.

Scientific Theories of Evolution

The theologians and philosophers may have prepared the way for theories of evolution, but those theories for their full development had to wait for the work of the natural scientists. Osborn says that it was Buffon (1707-1788) who, although his views varied from time to time and from book to book, laid down the basis of modern evolutionism in zoology and botany; he first pointed out, on a broad scale, the fact that species change in relation to changes of environment, and first worked out a definite theory of the causes of this mutability.[2]

The founder of the modern theory of the descent of one species from another was the great Lamarck (1744-1829), with his doctrine of evolution by use or disuse of organs and the transmission of characters thus developed. He held that the production of a new organ or part results from a new need or want which continues to be felt and from the new movement which this need initiates and causes to continue; that the development of organs and their force or power of action are always in direct relation to the employment of these organs; and that what has been acquired or altered in the organization of individuals during their life is preserved by generation and transmitted to the offspring of those which have undergone those changes.[3]

Charles Darwin and His Successors

The next great figure was Charles Darwin (1809-1882). Certainly, no man in the history of science has been estimated with such wide variations between the extremes of veneration and vituperation, neither of which

[2] *Same,* p. 130f.

[3] *Same,* p. 166.

extremes was perhaps altogether deserved. A few sentences from the great *Origin of Species*, first published in 1859, will serve as the best introduction to his writing:

"Man does not actually produce variability; he only unintentionally exposes organic beings to new conditions of life, and then nature acts on the organization and causes variability. But man can and does select the variations given him by nature, and thus accumulate them in any desired manner. . . ."

"There is no obvious reason why the principles which have acted so efficiently under domestication should not have acted under nature. In the preservation of favored individuals and races, during the constantly-recurrent Struggle for Existence, we see the most powerful and ever-acting means of selection. . . . More individuals are born than can possibly survive. . . . The slightest advantage in one being, at any age or during any season, over those with which it comes into competition, or better adaptation in however slight a degree to the surrounding physical conditions, will turn the balance."

. . . "If then we have under nature variability and a powerful agent always ready to act and select, why should we doubt that variations in any way useful to beings, under their excessively complex relations of life, would be preserved, accumulated, and inherited? Why, if man can by patience select variations most useful to himself, should nature fail in selecting variations useful, under changing conditions of life, to her living products? What limit can be put to this power, acting during long ages and rigidly scrutinizing the whole constitution, structure, and habits of each creature,—favoring the good and rejecting the bad? . . ."

. . . "New and improved varieties will inevitably supplant and exterminate the older, less improved, and intermediate varieties; and thus species are rendered to a large extent defined and distinct objects."

"It is interesting to contemplate an entangled bank, clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent on each other in so complex a manner, have all been produced by laws acting around us. These laws, taken in the largest sense, being Growth and Reproduction; Inheritance which is almost implied by reproduction; Variability from the indirect and direct action of the external conditions of life, and from use and disuse; a Ratio of Increase so high as to lead to a Struggle for Life, and as a consequence to Natural Selection, entailing Divergence of Character and the Extinction of less-improved forms. Thus, from the war of nature, from famine and death, the most exalted object which we are capable of conceiving, namely, the production of the higher animals, directly follows. There is a grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved." [1]

The views of Darwin may be summed up in the statements that individuals must struggle with others for food and safety; that individuals of any given species exhibit

[1] C. Darwin, *The Origin of Species,* second edition, 1860, pp. 405ff, 425.

chance variations; that some of the variations help the organisms which have them in the struggle for existence, making possible what Herbert Spencer called the survival of the fittest; that these favorable variations are transmitted to the offspring of the new generation; and that the gradual accumulation of these favorable variations makes organisms differ so much that they must be classed in different species.

The extracts and summary show that Darwinism is by no means equivalent to evolutionism. We may go on to note that Darwinism, as distinct from evolutionism, is not universally held, even among biologists. The prevailing opinion among them now is that while the Darwinian struggle for existence is real and very important, it is often modified by coöperation between individuals and even between species; that the range of chance variations exhibited in any given species must not be regarded as unlimited; and that some accumulations of variations are, so far as any one can see, of no use in the struggle for existence, and represent hindrances rather than helps, so that it is perhaps not the organisms which in some respects, at least theoretically, are the "fittest" which survive.

Moreover, it is not clear that favorable chance variations are necessarily transmitted to succeeding generations. Since the time of Darwin most biologists have followed August Weismann (1834-1914), who maintained that in the organism there is a basic distinction between "germ-cells" and "somatic cells"; the former, concerned in reproduction, are in most cases passed on virtually intact from generation to generation; the latter, making up the remainder of the body outside the germ-

cells, collectively serve merely as a container or carrier of the germinal material. The somatic cells of any individual may be modified by environment or use, or both, during that individual's life history; but it is a serious question whether such somatic modifications affect the germ-cells so as to be transmitted to new generations. This is the problem of the "inheritance of acquired characters". If one holds, as most biologists do, that acquired characters are not inherited, this does not mean a rejection either of evolutionism or of Darwinism, for the changes due to inherent causes may still be going on in rearrangements of the constituents of the germ-cells. But the view that acquired characters are not inherited points at least to the view that evolution, if it occurs, is not rapid but very slow, and is based upon changes in the organism which are not superficial, but profound.

Finally, even if it is true that from accumulations of variations new species result, this must not be thought of as a process occurring in some single individual or pair of individuals and resulting in a line of individual offspring well marked off from others of different species. The lines between species are indefinite, and species are, as Poulton says,[1] better regarded as changes of masses rather than of individuals. In such a theory, a shift of species would be comparable to a shift in the center of population of the United States. In order to locate or specify the change, a vast amount of data would have to be studied by statistical methods.

While these modifications of the Darwinian views have affected the importance ascribed to some of Darwin's opinions, they have not noticeably affected the great im-

[1] Quoted by J. W. Gregory, in F. Mason, *Creation by Evolution*, p. 119.

pression which Darwin made upon the scientific world, nor the great influence which he had upon scientific and popular thought. He remains to-day perhaps the ideal scientific observer—patient, thorough, resourceful, and, above all, as a saying current among biologists has it, his own best critic. And the basic arguments for the evolution of species as laid down by Darwin and augmented and modified here and there by his successors constitute one of the conspicuous examples of scientific reasoning of all time. This does not mean that there is necessarily anything sacred or impregnable about the arguments for evolutionism. If arguments against evolutionism equally compact and cogent, and equally well supported by evidence, could be brought forward by the opponents of evolutionism, the scientists most thoroughly imbued with the scientific spirit would be the first to welcome them.

Arguments for Evolution: Fossils

The evolutionists may be said to begin by going far back to a study of organisms which are no longer found among the living species, but which lived in the earth in very remote times, as indicated by their fossilized remains. The formation of fossils affords one of the most fascinating portions of the data of the sciences. It appears that some of the organisms before being devoured were caught in soft sand or mud deposited at the shore lines by the action of water, just as today snails are buried in the rippled sands piled up on the beaches of our lakes. The sand or mud gradually hardened into rock, and in one way or another the harder parts of the imprisoned organisms left the impressions of their forms in the rock structure as fossils. In the course of succeed-

ing ages many different layers of rock, often of different composition, but each containing its characteristic fossils, were thus deposited one upon another, the later tending to bury the earlier.

Geologists tell us that if all the rocks which were thus laid down could be found in their original order and thickness, this "geological column" would be some sixty miles high. But nowhere in the earth's crust, so far as is known, are there such undisturbed rocks—the geological processes, although often imperceptibly slow, have been far too violent in their results. In the course of ages there have evidently been periods of glaciation, when the rocks were ground down by huge ice sheets, such as that which covers the interior of Greenland at the present time. Between the periods of glaciation, which seem to have recurred at long intervals of many thousands or even some millions of years, there has been erosion, or the wearing away of various layers in various localities by the action of water, wind, etc. By faulting, or slipping of one layer on another, the original thickness and order of the layers has been modified. Especially by bending, folding, arching, and overthrust, layers which were once well down below others are now on top of them. The local processes have been conditioned by the great general "diastrophisms", or tendencies of the continents to be gradually raised or lowered through long periods and over wide areas. The rocks, taken the world over, are thus found in a good deal of confusion. One thing at least is clear; when for any reason the rocks of various strata break up, they tend to break along the planes in which the organisms were buried millions of years ago, thus helping to expose to view

many fossils which otherwise might never have been detected.

In spite of the confusion of the rocks as they actually are found now, the geologists are confident that they can in theory reconstruct the column and identify the rocks practically in the order of age. And the biologists—or strictly speaking, the paleontologists—affirm that when this is done, on the whole the simplest fossils are found in the oldest rocks, and the sequence of fossils in the order of increasing complexity can be correlated with the sequence of rocks in the order of decreasing age. Moreover, changes in the fossils can at least sometimes be correlated with geological evidence of changes in environmental conditions, *e.g.*, changes of temperatures associated with glaciation, which at least when taken statistically over long intervals of time, might have caused changes of species. This correlation of strata of rocks and kinds of fossils is the great basic argument for the evolution of species. Because of the immense reaches of time involved, it may be called a long-range argument.

The creationists have attempted to challenge the conclusions both of the geologist and the paleontologist, and in particular have maintained that each of these scientists argues the order of his own series from that of the other, so that the oldest rocks are identified by the fact that they contain the simplest fossils, while the simplest fossils in turn are identified by the fact that they are found in the oldest rocks. Sometimes also it is said by the creationists that there is no consistent or universally accepted criterion enabling us to tell whether two rather closely related organisms belong to different species or merely to different varieties, and that there-

fore the biological theories are untrustworthy. These criticisms of the evolutionist argument are now usually motivated by a theological interest; the creationists are for the most part interested in maintaining the literal authority of the account of the origin of each species by an act of special creation, as recorded in the Book of Genesis.

Heredity and Variations in Living Species

Again, the evolutionists argue that differences like those observed between various fossils can also be found among many living plants and animals as these are actually observed in their natural habitats, so that the fossil record and the data afforded by the living species can, so to speak, be joined and seem to point in the same direction. Some progressive changes may in certain cases be secured by selective breeding, although it is generally agreed that these differences are not great enough to amount to differences of species. This line of argument was especially emphasized by Darwin; he, and in general the evolutionists after him, have argued that varieties produced by artificial breeding, although they do not constitute differences of species, are nevertheless indications of the ways in which species have originated under more natural conditions and with vastly longer periods of time involved.

Some details here have been cleared up by other investigations. Gregor Mendel (1822-1884), an Austrian monk, by a study of the data of selective breeding of sweet peas, was able to show that the characteristics marking off different varieties, for example as tall or short, etc., could be accounted for on the theory that each

individual carried germinal material inherited in approximately equal quantities from each of its two parents. More recently Professor T. H. Morgan and his associates at Columbia have been able to show that Mendelian variations in the fruit fly *Drosophila* can be correlated with changes in the pattern of the chromosomes, or thread-like bodies in its germ-cells, and have inferred that these changes of pattern are changes in the arrangement of genes or constituents of the chromosomes. It should be noted that Mendelian heredity has primarily to do only with the appearance of varieties, not of species, but the evolutionists suppose that the same principles carried further would at least help to account for the appearance of species.

The creationists insist that no one has ever seen an organism of one species develop from an organism of another species. For the creationists the infertility or sterility of hybrids like the mule is enough to show that crossings of ancestral species are not nature's way of producing new species. The counter-argument of the evolutionists, to the effect that hybrids are not always infertile or sterile, seems not to be recognized by the creationists.

Moreover, the creationists maintain that the simplest assumption for a theory of evolution would be the Lamarckian view that changes produced in the constitution of an organism of one generation are transmitted to its descendants; but all attempts either by observation or experiment to demonstrate the inheritance of acquired characters have failed to convince the majority of biologists, and most of the evolutionists are driven back to suppose that variations and ultimately differences of

species are due to varying combinations of original germinal material which determine bodily characteristics, as the combinations are influenced by various environmental conditions.

Even with the data of Mendelism before us, it may be argued,—and by some of the evolutionists as well as the creationists—that the process of heredity is still shrouded in mystery. Just what brings about the different combinations in the germ-cells, just what the operations of the germinal material on the somatic cells are, just what combinations are effective, and just what the influence of the environment is, are obscure points which seem to baffle all attempts to clear them up. This is a part of the situation summed up by Bateson in his widely quoted and sometimes misunderstood address.

"As we have come to know more of living things and their properties," he said, "we have become more and more impressed with the inapplicability of the evidence to these questions of origin. There is no apparatus which can be brought to bear on them which promises any immediate solution. . . .

"Biological science has returned to its rightful place, investigation of the structure and properties of the concrete and visible world. We cannot see how the differentiation into species came about. Variation of many kinds, often considerable; we daily witness, but no origin of species. Distinguishing what is known from what may be believed we have absolute certainty that new forms of life, new orders, and new species have arisen on the earth. That is proved by the paleontological record. . . . In dim outline evolution is evident enough. From the facts it is a conclusion which inevitably follows. But

that particular and essential bit of the theory of evolution which is concerned with the origin and nature of *species* remains utterly mysterious. We no longer feel, as we used to do, that the process of variations, now contemporaneously occurring, is the beginning of a work which needs merely the element of time for its completion; for even time cannot complete that which has not yet begun.

"Though our faith in evolution stands unshaken, we have no acceptable account of the origin of 'species'.

. . . "The survival of the fittest was a plausible account of evolution in broad outline, but failed in application to specific difference. The Darwinian philosophy convinced us that every species must "make good" in nature if it is to survive, but no one could tell how the differences—often very sharply fixed—which we recognize as specific, do in fact enable the species to make good. . . .

. . . "Analysis has revealed hosts of transferable characters. Their combinations suffice to supply in abundance series of types which might pass for new species, and certainly would be so classed if they were met with in nature. Yet critically tested, we find that they are not distinct species and we have no reason to suppose that any accumulations of characters of the same order would culminate in the production of distinct species.

"I have put before you very frankly the considerations which have made us agnostic as to the actual mode and processes of evolution. When such confessions are made the enemies of science see their chance. If we cannot declare here and now how species arose, they will obligingly offer us the solutions with which obscurantism is

satisfied. Let us then proclaim in precise and unmistakable language that our faith in evolution is unshaken. Every available line of argument converges on this inevitable conclusion. The obscurantist has nothing to suggest which is worth a moment's attention. The difficulties which weigh upon the professional biologist need not trouble the layman. Our doubts are not as to the reality or truth of evolution, but as to the origin of species, a technical, almost domestic, problem. Any day that mystery may be solved . . . ".[1]

In other words, the evolutionists do not doubt for a moment that evolution has occurred; but when it comes to the question of just precisely *how* evolution occurs, they are at a loss to answer. Bateson maintained stoutly that the creationists, whom he called obscurantists, had no contribution worth considering. But the creationists point to their old-fashioned, simple, easy and long-sanctioned explanation in terms of God's initiating and intervening activity, and claim that this points the way out of the uncertainties in which the evolutionists admit themselves to be involved.

The Time-Factor in Evolution

By way of counter-argument coming from the side of the evolutionists, it may be noted that they are not troubled by the fact that no one has observed the origin of a new species (the giant evening primrose discovered by DeVries, which was once thought to be a new species, is now classified rather as a mutant, or variety). According to the evolutionists, the fact that changes of species

[1] W. Bateson, "Evolutionary Faith and Modern Doubts," *Science*, N. S., Vol. 55, 1922, p. 57ff.

are not observed can trouble only those who take inadequate account of the natural conditions, and particularly the length of time involved. As an illustration of this point, the case of the Gaspé peninsula, near the mouth of the St. Lawrence river, may be cited. The last series of glaciations, ending perhaps 30,000 years ago, left the peninsula undisturbed and isolated, but covered the neighboring region of Nova Scotia and extended southward to New Jersey. So far as glacial evidence goes, the Gaspé peninsula appears to have been undisturbed for about 1,000,000 years, while Nova Scotia has been free from ice only about 30,000 years and in that time has derived its now isolated coastal plain flora from southern New Jersey. Now when the plants of New Jersey and Nova Scotia are compared, no undoubted case of a species peculiar to the one and not found in the other is observed; but when the plants of the Gaspé peninsula are compared with those of either of the other two regions, several species peculiar to the peninsula can be identified. This suggests that a period of 30,000 years has not been long enough for a new species to appear, but that a period of 1,000,000 years may be sufficient for such a change.

Probably the most striking development in recent investigations is the work of H. J. Muller, who has shown that the ordinary rate of production of variations in fruit flies may be increased 150 times if they are subjected to the action of X-rays. This again is a matter of varieties, not species, but the former seem to point the way to the latter. Evidently the course of natural evolution, if it occurs at all, is slow beyond any of our ordinary conceptions.

These considerations of the bearing of time upon

biological evolution also affect the arguments concerning the infertility of hybrids. According to evolutionist theories, although not according to evidence, it is quite possible that once in perhaps hundreds of thousands of years fertility in a hybrid strain might continue for enough generations to establish a new species. Similar possibilities may at least be readily imagined for the inheritance of acquired characters.

Geographical Distribution

The data from the Gaspé peninsula suggest another line of evolutionist argument, namely that from geographical distribution. It is urged that not merely do the earth's surface rocks taken vertically afford geological indications of the evolution of species, but also that the earth's land areas taken, so to speak, horizontally, afford geographical indications of such evolution. For one thing, unique species are found in isolated regions, particularly on islands; the kangaroos of Australia are the best known example, but there are many others. In the Galapagos Islands "there are ten different kinds of giant tortoise on ten different islands, and those that are on the islands that are farthest apart are most unlike." [1] The connected land surfaces and areas of the earth exhibit somewhat similar progressive differences according to distance, isolation, etc., although here the differences are more likely to be obscured by other factors. According to the evolutionists there is a correlation of the age of a species and its distribution, as well as between distance of separation and differences of characteristics, so that all

[1] J. A. Thomson, "Why We Must be Evolutionists," in F. Mason, editor, *Creation by Evolution,* 1928, p. 15.

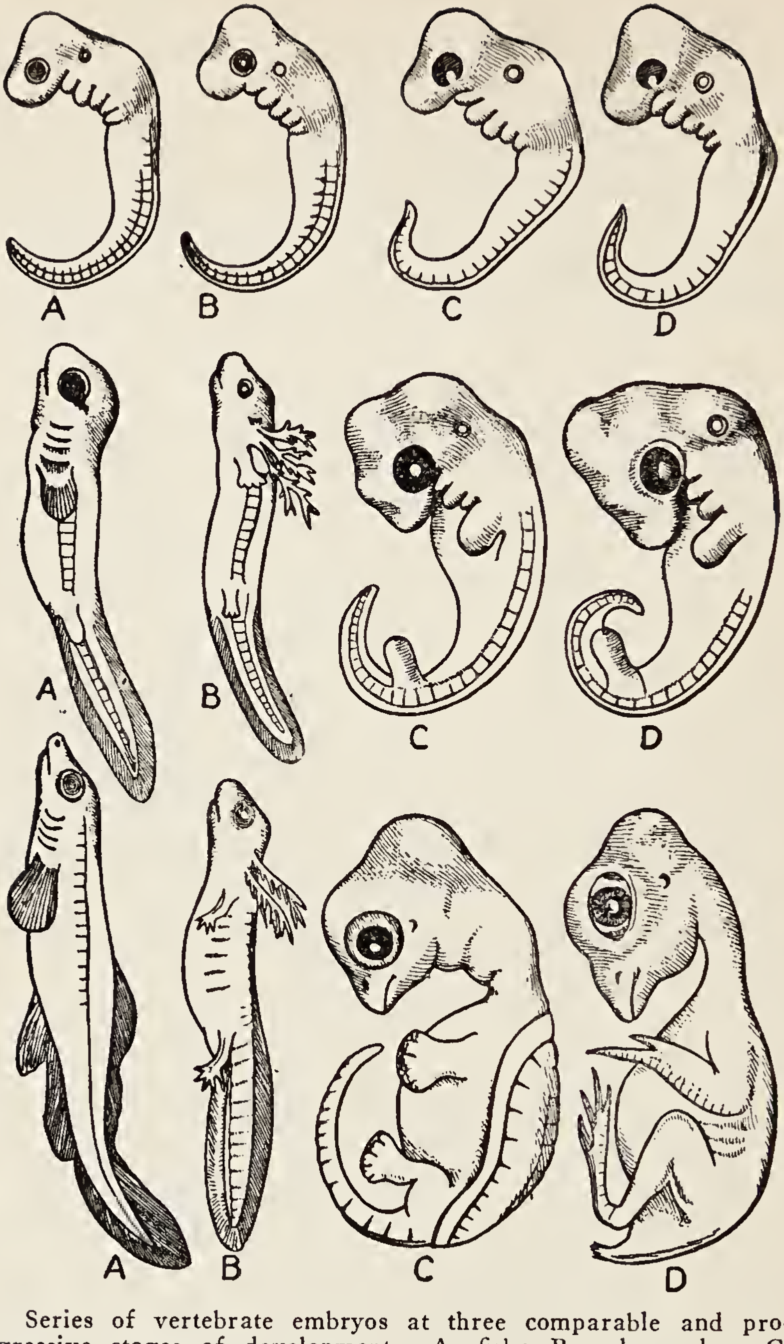
available data point in the direction of gradual change of species in the course of diffusion into a given environment. Practically the only answer which the creationists have to the argument concerning geographical distribution is that the creative agent or power, of course not working in a vacuum, employed geographical conditions to further its own ends.

"Transitional" Species

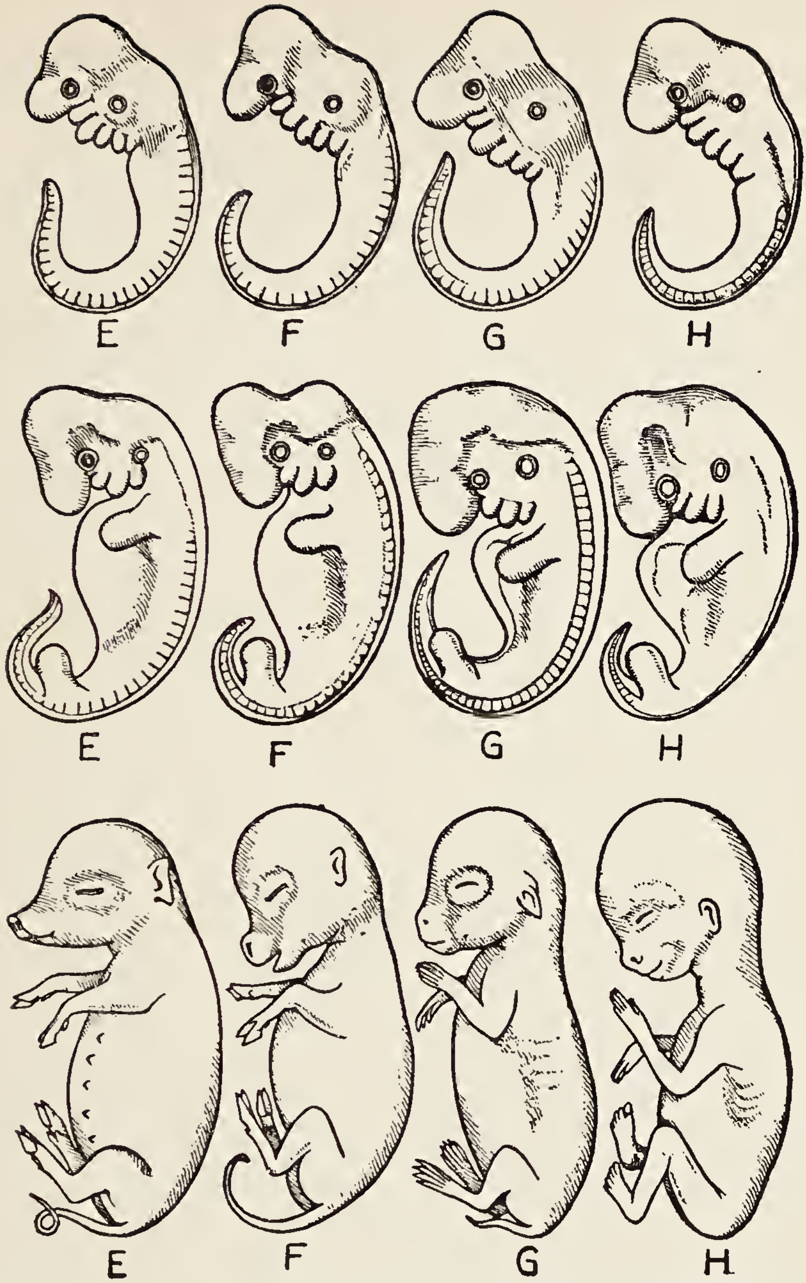
Another evolutionist argument concerns the curious "transitional species", which seem to be links between better established forms. It is, for instance, hard to say whether *Euglena* is a plant or an animal. The fossil bird *Archæopteryx* was well equipped with teeth. One of the strangest creatures now found anywhere is the duck-billed platypus of Australia, which has a bill and feet similar to those of an aquatic bird, and still is covered with fur, and which lays eggs and hatches its young, and then nurses them like a mammal! The creationists here may reply to this argument by the simple assumption that the creative agent or Power varied the organismic patterns gradually, perhaps even in a kind of divine experimentation.

"Recapitulation" in Embryos

Always an impressive argument, and for some investigators the strongest of all arguments for evolution, is that from what is called the "law of recapitulation" in embryology. There have been some disputes regarding the evidential value of the data; the embryos of some species certainly exhibit features which are not found in ancestral embryos or larvæ. But in general it appears to



Series of vertebrate embryos at three comparable and progressive stages of development. A, fish; B, salamander; C, tortoise; D, chick.



E, hog; F, calf; G, rabbit; H, Human. (After Haeckel, from Romanes' *Darwin and After Darwin.* Courtesy of Open Court Publishing Co.)

be true that an embryo of an individual of a given species in the course of its development goes through stages characteristic of the embryos of species which precede it in time and according to the evolutionists are its ancestors. This is summed up in the dictum that ontogeny broadly recapitulates phylogeny, but the summing up is not quite accurate if "ontogeny" is meant to include the post-embryonic development of the individual and "phylogeny" the post-embryonic development of the race. Recapitulation, in other words, applies to embryos rather than to adult forms, as shown in our illustrations.

In the case of man the data are striking. Each individual ontogeny begins with a fertilized egg which although it is by no means to be identified with a unicellular organism, is a single cell. At the blastula, or hollow sphere stage, the embryo is most like the "colonial" organism, *Volvox*. After infolding of the wall of the blastula the embryo, in the gastrula stage, is like a coelenterate, and begins to show the differentiation into outer, intermediate, and inner layers which to a greater or less degree condition all future differentiations of the organism. Embryonic man at one time possesses gill slits like a fish, at another a tail, which occasionally persists even at birth. The development of the human brain through the various embryonic stages affords a particularly striking example of recapitulation, representing at successive periods the major steps in the development of the brains of more primitive groups of vertebrates. Here again the creationists have a simple and ready answer, to the effect that the pattern is varied only gradually under divine direction.

Vestigial Organs, etc.

The adult organisms are not without their contribution to the arguments of the evolutionists, for in the more complex organisms there are numerous organs which seem to have no function in these organisms, but which when compared to similar or homologous organs in earlier species appear now to be merely survivals. In the human body there are scores of vestigial muscles and other organs; the best known is the vermiform appendix, representing the remnant and vestige here of an organ useful in species like the rabbits, which have to digest coarse foods. Sometimes the creationists argue that we must not be too sure that an organ of the human body is vestigial and functionless, and sometimes it is true that mistakes have been made when conclusions of this kind have been too hasty. But the weight of opinion is all on the side which regards most of these organs as purely vestigial, and it is at least hard to see what purpose most of them could serve.

It has been found that the "blood count" of corpuscles is similar or nearly equal for bloods of species which on other grounds are held to be closely related, and varies with remoteness of relationship. That of man is most nearly approximated among the other known species by the anthropoid apes. There is some indication that nearly related species have significant relationships in the number of the chromosomes in their germ-cells; new species may possibly arise through the loss of a chromosome or through some of the duplications of chromosomes resulting from failures of germ-cells to divide normally in the processes of reproduction.

The psychologists in their work on reflexes have fur-

nished another argument for evolutionism, in the fact that the reflexes of species which on other grounds are held to be closely related are found to resemble one another. An example often cited is that very young children can at first swing by their arms like monkeys. Some of the evolutionists have sought to make capital out of the fact that children, if not rendered unnatural by modern methods of child rearing, like to be rocked; these evolutionists have regarded this as a mark of kinship with ancestors that lived in the swaying branches of the trees.

Such are the principal detailed arguments for the evolution of biological species. It is always in order to mention one other argument, of a different type—the argument which consists of a synthesis of all the foregoing detailed arguments, taken together. Most evolutionists who have considered the logic of the subject as well as the state of the data are ready to admit that there are no absolute proofs of evolutionism, and that no one of the foregoing arguments for it is finally conclusive. But they maintain that no other theory accounts so neatly for the data, and moreover hold that the fact that so many different arguments converge, or can be regarded as converging, in the same direction surely ought to be given some consideration. For instance, the argument for the evolution of the horse based on a correlation of fossils in the order of complexity and rocks in the order of age receives considerable reinforcement from the fact that the embryo of a horse exhibits something of a recapitulation of such stages. It is not outside the bounds of logical possibility that two arguments, each of which taken by itself is weak, may strengthen one

another; and the evolutionists claim for their arguments the benefit of such a possibility.

Creationist Arguments Against Evolutionism

Where the creationists have important answers to particular arguments, these answers have been indicated above, but there remain certain general arguments of the creationists which must now be considered. One which may be dismissed without much consideration is the so-called "monkey-argument", to the effect that the evolutionists by comparing men and the apes and suggesting ancestral connections have offended the dignity of man. It is often urged in reply to this that the evolutionists trace not man's descent, but his ascent, and his descent or ascent not from an ape but from an "ape-like ancestor"; these answers are mainly verbal. The more adequate answer to the creationists is that one should gather one's ideas of monkeys and apes not from zoological gardens but from zoological laboratories, where the marvellously coördinated structures of the ape's body can be exhibited and studied technically. The creationists really need to be reminded that ugliness, like beauty, is only skin deep.

When the creationists argue that evolutionism offers no clear or adequate account of either beginnings or endings, the evolutionists may in principle admit the charge. This is first because, as we have pointed out above, evolutionism is not particularly interested in origins, but in outcomes, and second because any account of future outcomes or events must necessarily involve some uncertainty and hence be left indeterminate and vague. The accounts of beginnings and endings to which the creationists object

belong, strictly speaking, not to evolutionism but to a kind of naturalism. Evolutionism as such could be readily reconciled with a doctrine of divine decrees and universal salvation; or it might be held along with doctrines of pure chance and uncertain cosmic adventure.

The Authority of the Bible

The chief creationist argument is that evolutionism contradicts the literal authority of the Bible; Genesis 1, 25 says that God made the beasts of the earth after their kind and the cattle after their kind and everything that creeps upon the earth after its kind—as clear a statement of the doctrine of special creation as one need expect to find in any ancient writing. There have been more or less ingenious attempts to reconcile evolutionism and Genesis, but they turn upon questions of the meanings of Hebrew words which only experts are fitted to approach. And even if all the difficulties about the meanings of words could be settled to the satisfaction of every one, it would still be necessary for the creationists to defend the science of the Bible at so many other points that the struggle seems hardly worth while. The Bible plainly implies the view that the universe is geocentric; it has theories of the structure of earth and sky which have long since been abandoned; it traces certain diseases to possession by demons, and gives every evidence of being an ancient, prescientific account of the world rather than one checked by sound results of observation and experiment.

It would seem to be for a religious man the more wholesome and constructive view to understand the Bible as something other than a text-book of science. Here one may, for example, hold the doctrine that the Bible is

inspired and authoritative as regards salvation, and leave other questions open. It may be worth noting also that if one insists that the Bible must be taken as a text-book of science, one must face the fact that the Book of Genesis could not as it stands be taken as a text-book of ethics; and if God was content to make ethics a matter for progressive development, it is reasonable to think that science might have been left to develop in the same way. Sometimes the evolutionists introduce what they regard as a clinching argument when they regard the whole Bible as itself a document in the evolution of religion. We shall consider this view in Chapter VII.

In any discussion of creationism when the view is held on religious or theological grounds, one must remember that strong psychological factors are involved. It is the view which comes down to us with the sanctions of a long past. It has been held by generations of those whom most of us revere and love. It is urged upon many of us and stamped in by powerful means of organized social suggestion. It is held up as our duty to accept it, and declared to be at our peril that we reject it. The motives with which it is associated are so deep seated that it is possible to become very much excited over the doctrine, and doubtless also to exaggerate its importance.

The Case for Creationism

But even if all these psychological factors are duly discounted, and the prejudice of the monkey-argument dissipated and the Bible estimated in somewhat less extravagant terms, the fact remains that in some respects there is more room for creationism than is usually realized. The creationists are not slow to point out the

important fact that there are many gaps in the data. The evolutionists themselves say that naturally only a fraction of the organisms at any given period perished in such ways as to form fossils, and naturally only a fraction of the fossils which were formed have been exposed. Furthermore, granted the available data, there are among the evolutionists many differences of opinion about classification into species and the details of serial arrangement. The evolutionists admit this, too, but insist that new data all the time coming to light make better and better arrangements possible and not merely help to fill the gaps but usually seem to fit into them much as would be expected. At the same time, it has to be admitted that none of the proposed arrangements provides a series in every respect continuous, or one which is not open to the possibility of new insertions or to the action of intervening causes. We know so little concerning the causes at work in any of these processes that almost any assumption may be entertained. What then is the reason, if there is any, for rejecting creationism and accepting evolutionism?

Conclusion

There appears to be such a reason, but it is only indirectly afforded by the data, and need not be regarded as a matter of evidence. The great argument comes from considerations of methods of handling the data, and is not so much a matter of evidence as a matter of inference. The inference as to method is that *the fewer causes which are involved to account for an apparent result, the better.* This is the principle of economy of explanation, or the "law of parsimony" enunciated centuries ago by William of Occam and since known as

"Occam's razor". All modern science really tends to conform more or less closely, and more or less unknowingly, to it.

The choice between creationism and evolutionism, then, simmers down to a choice as to whether the data are to be interpreted as the work of two sets of causes or one. When the problem is phrased in this way, it is seen to be only a step from the one choice to the other; it is virtually only a step from naturalism to supernaturalism or *vice versa*. It is a choice which can hardly be determined with any absolute finality. Neither naturalism nor supernaturalism can be proved; the most one can do is not to prove but to approve, or not to disprove but to disapprove. Perhaps the one consideration which is of any real help is derived from a survey of the history of thought; although it must be confessed that the history of thought moves in a way which is anything but straightforward and consistent. Taken over a wide range, the history of thought cannot be said to move unmistakably in the direction of monism, *i.e.*, the interpretation of the world in accordance with any one consistent principle; the present-day pluralisms are enough to dispose of any such view. There are always strong tendencies toward monism, but on the other hand new facts are likely to appear which offset such tendencies by showing that the data are more varied than was supposed. The one thing that can be said is that among the minority of persons who hold or seek modern views there is a prevailing trend toward economy of explanation, and toward interpretations which depart as little as possible from the actual empirical data. Supernaturalism is still plausible and creationism is still tenable, but among the

minority there is a formidable movement away from these interpretations. Evolutionism, as far as it is concerned with the problem of the origin of biological species, may represent a kind of compromise between supernaturalism and naturalism; it breaks with creationism by emphasizing inherent causes, but if any one insists it still has a place for supernaturalism, by its admission of the open possibility of a supernatural Initiating Cause.

CHAPTER VI

THE EVOLUTION OF LIVING ORGANISMS

(*Concluded*)

III. THE PAGEANT OF LIVING FORMS

No survey of the theory of evolution of living organisms is complete without an attempt to portray in some large way the spectacle of the successions of species as they arise, attain to dominance, and either become unimportant or cease altogether to exist. It is a spectacle which moves on a vast time-scale through a succession of geological eras and grows in impressiveness with each new discovery of data.

"All the World's a Stage"

The first point to note is obvious, when one stops to think of it, but is all too easily overlooked; it is that the process occurs in the earth. We have seen that in the theory of evolution the later stages of the earth's development—*i.e.*, the various strata of rock in the geological column—are correlated with the stages of the development of the organisms. The living organisms do not appear or live on the earth; they live in it, below its atmosphere if not actually in its waters. According to the extreme evolutionists, the earth is the mother of organisms, and the life-process is really one of the earth

processes. This viewing of the biological process as a whole in its great geological setting is one of the newest and rarest, as it is one of the most absorbingly interesting, ways of studying the subject. The earth need not be thought of as inert, and above all not as hostile to the life process; according to the evolutionists, the more adequate view is that the earth is itself a life-producer. This brings us close to the root sense of the word "nature"; it means "that which is about to be born".

The Earliest Forms of Life

But not every period was life-sustaining; the earliest rocks, formed principally under the action of heat, apparently do not contain fossils. Geologists call these rocks Archæan; the rocks which are supposed to represent the period of the beginnings of life are called Archæozoic. All indications point, as we saw, to infra-cellular or unicellular organisms as the earliest living forms. These organisms doubtless appeared in shallow water or in porous soil near the margins of the primeval seas when conditions of temperature, moisture, and pressure became such as to support them. The estimates of the time at which this change occurred may range all the way from one hundred million years to a billion years ago; all attempts to measure the process in the time-scale of years are open to serious question. The first organisms were composed largely of water and even though they developed simple organs had no parts hard enough to leave fossil remains; hence for the most part they perished without leaving any trace. The first unicellular organisms gathered into colonies, which, presumably by specializations of function of various parts

and by differentiation of outer and inner and then intermediate portions, in time evolved into multicellular organisms. Some of them were of the hollow sphere form and free swimming, but others settled down on the sea bottoms and gradually became adapted for locomotion in the particular special direction indicated by the concentration of nervous tissue in the forward end and the formation of the head.

Some authorities, assigning the beginnings of life to the Archæozoic Era, which is supposed to have lasted a number of millions of years (see accompanying Table of Geological Time), distinguish next an era called the Proterozoic, which is supposed to have preceded the universally recognized Palæozoic, or Era of "old life". In the Proterozoic rocks there are some indications of calcareous secretions of algæ or simple plants; and in the

TABLE OF GEOLOGIC TIME

Era	*Schuchert-Walcott-Osborn (1917)*[1]	*Schuchert* (1923)[2]	*Berry* (1928)[3]
Cenozoic	3,000,000 years	5%	3,000,000—5,000,000 years
Mesozoic	9,000,000 years	12%	5,000,000—10,000,000 years
Palæozoic	18,000,000 years	28%	20,000,000—25,000,000 years
Proterozoic	30,000,000 years	20%	25,000,000 years
Archæozoic		35%	50,000,000 years

[1] See H. F. Osborn, *The Origin and Evolution of Life,* 1917, p. 153.
[2] From the 1923 edition of R. S. Lull, editor, *The Evolution of the Earth and Its Inhabitants,* p. 69.
[3] See F. Mason, editor, *Creation by Evolution,* 1928, p. 160.

upper levels of the "Belt series" of formations in Montana, exposed on the side of a mountain and lying nearly 8000 feet below the Cambrian, fossilized traces of worm burrows and trails have been found.[1]

The earliest well-recognized fossils occur in the so-called Cambrian rocks, but here also there are grounds for thinking that simpler organisms antedated those represented. For instance, graphite deposits indicate that there had been some organic processes. Again, crustaceans, mollusks, and worms, which are relatively complex animals, are found in the Cambrian rocks and may be supposed to have been preceded by simpler forms. The Cambrian trilobites, so called from their three-lobed structure, are relatively far advanced, and their larval stages which can sometimes be distinguished indicate, according to the recapitulation theory, that there were simpler ancestral forms.

The Palæozoic, or Era of Fishes

The Palæozoic Era is divided into four other periods besides the Cambrian with which it began. The other four, in the order of succession, are the Ordovician, Silurian, Devonian, and Carboniferous. Each is named from the locality where its principal fossils were first found, or are most abundant, or from the characteristics of those fossils. In the Cambrian rocks, so called from Cambria, the Latin word for Wales, there are evidences of marine plants, and of many trilobites. In the upper Cambrian strata, according to Lull,[2] the "lime-secreting

[1] W. K. Gregory, "The Lineage of Man," in Mason, *Creation by Evolution,* p. 271.

[2] R. S. Lull, in *The Evolution of the Earth and Its Inhabitants,* 1918. Chapter IV.

habit" becomes perfected, with the result that in the Ordovician period mollusks and shelled animals such as cystoids, brachiopods, and cephalopods rise to dominance. The trilobites lead in the number of genera represented and here attain their greatest development. Lull thinks that the great up-arching (which, among the other effects, helped to produce the Grand Canyon of the Colorado River) rendered the terrestrial waters more active in their flowing toward the seas and prompted the development of animals capable of weaving this way and that in the streams. Animals under such conditions might be expected to develop a central longitudinal axis jointed so that it could be easily bent, with symmetrically placed muscles on either side—the type of organization found in the vertebrates. Accordingly, the fishes arose during the Silurian period, where they existed along with sea weeds and land plants which have the characteristics both of mosses and ferns. The fishes at the margins of the seas were subjected to tidal variations; periodically they were covered by water and then daily left exposed in the air. This prompted the development of two sets of breathing apparatus, and the lung-fishes made possible the development of terrestrial vertebrates, which development was furthered by up-arching of the land and aridity.

The Devonian rocks exhibit the first abundant fossil land plants; some of them mark transitions from sea weeds to land plants, while others seem to be undifferentiated ancestral forms of many later mosses, ferns, etc. Scorpions, spiders, and a few insects are found in this period. In the Devonian the fishes attain their greatest development; according to the comparative anatomists

the sharks of this remote period already exhibit the anatomical ground-plan later found in man. The indications are, too, that with increased moisture and swampy forests, the setting was advantageous for forms at home both in water and on land. So the fins of some of the fishes seem to have become gradually adapted for use on land. The forward paddles began to be bent at what we in the later forms call elbows and wrists, while the hind paddles were bent in opposite directions at future knees and ankles. In the new feet may be traced some indications of the five-finger and five-toe pattern familiar in man. The result of these developments was a great class of animals capable of living under both sets of conditions—the so-called Amphibia, at the present time represented by newts, salamanders, frogs, and toads.

The Carboniferous period is so called because to it belong the "coal-bearing" strata with the fossilized trees, ferns, and giant club mosses which now constitute the coal deposits. It is subdivided into three ages, the Mississippian, Pennsylvanian, and Permian. In the Mississippian there seems to have been another period of widespread aridity, which led many animals again to seek the water, with consequent development of reptiles. On the other hand those which remained on land, if they were to survive, had to acquire means of rapid locomotion and had to be able to resist the winter. These conditions seem to have led to the appearance of warm-blooded animals (birds and mammals).

The Mesozoic, or Era of Reptiles

Toward the close of the Permian there seems to have been widespread glaciation, with disappearance of many

of the older forms of life. The era which succeeded is called the Mesozoic, or "Middle life", Era, subdivided into the Triassic, the Jurassic, and the Cretaceous periods. The Triassic, originally named from the rocks of three localities in Germany, is notable for the appearance of the primitive mammals—warm-blooded animals which are better equipped than the reptiles for regulating their bodily temperatures, and which after developing eggs within the body of the mother usually bring forth their young alive, and suckle and care for them during infancy.

The Jurassic period, so called from some rocks in Jura, Switzerland, is marked by cone-bearing plants or trees, and, as for animals, most conspicuously by the giant dinosaurs ("terrible reptiles"), the fossil remains of which are among the most impressive things in the world. These huge reptiles apparently lived in the sluggish streams. Many of them fed upon the vegetation along the banks, but a few species were carnivorous, feeding upon their less aggressive cousins. Some of them developed huge armored scales or plates for defense against their enemies. The largest known dinosaurs, judged by the skeleton in the Carnegie Museum at Pittsburgh, attained a length of about eighty feet. The discovery of whole nests of fossilized dinosaur eggs (Protoceratops) in the Gobi Desert of Mongolia has been one of the striking scientific "finds" of recent years. Most of these eggs are now in the American Museum of Natural History at New York City. One of the most significant points about the dinosaurs was the utter disproportion between bodily bulk and the size of the brain; doubtless this was no small factor in their extinction. The race

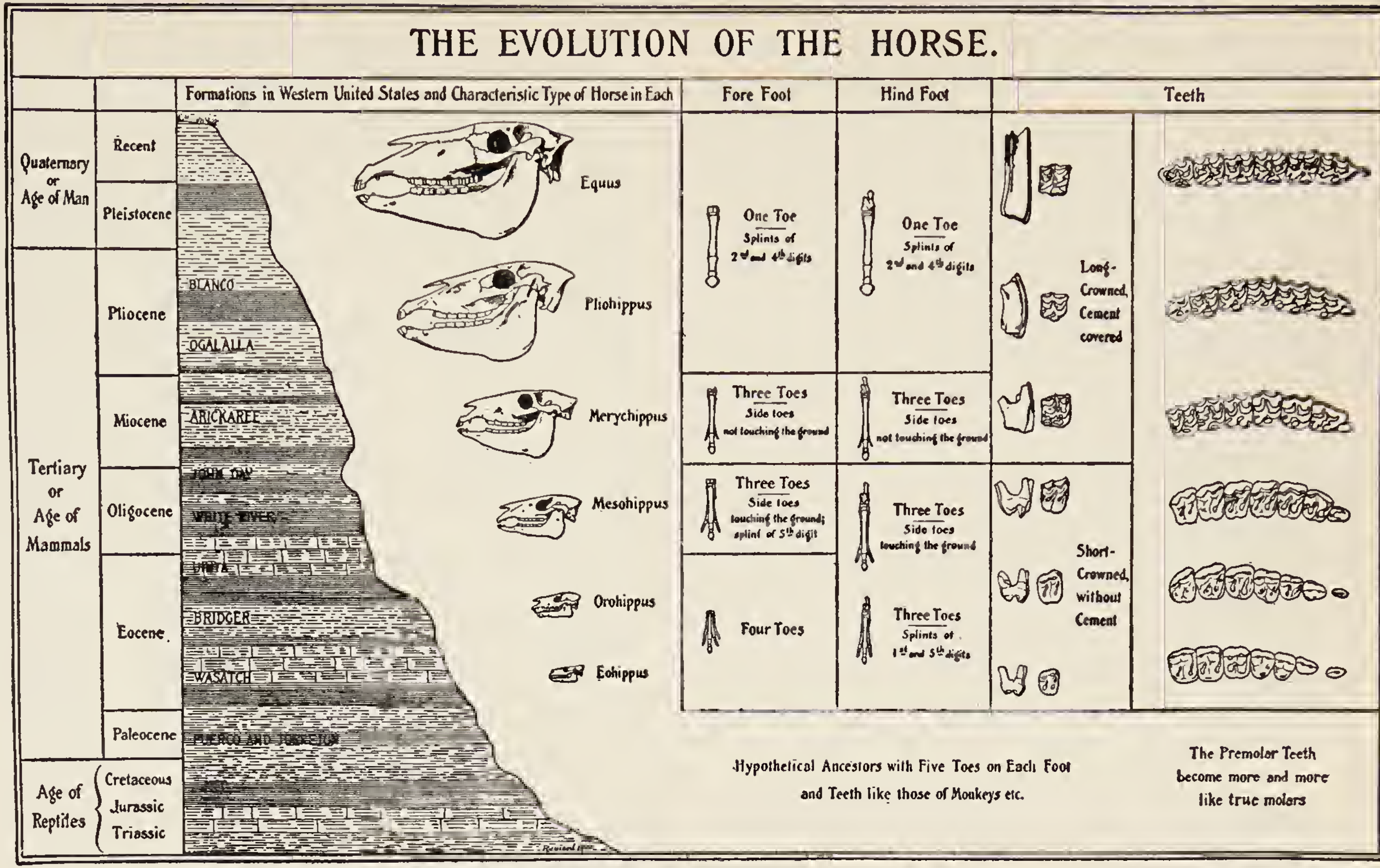
of life seems to have gone to animals capable of swifter and more varied coördinations.

In the Jurassic rocks also are the remains of curious toothed birds or reptile-birds which seem to mark a transition from the one class to the other. There were mammals in this period, but they seem to have remained almost stationary throughout the whole Mesozoic Era, perhaps because of the dominance of the dinosaurs. In the Cretaceous period, or period of the chalk deposits, appear the ancestors of our flowering plants. It was at the end of the Cretaceous that, for some reason, perhaps as we said involving their poverty of nervous equipment, the great dinosaurs became extinct. Fossils found in one of Dr. R. C. Andrews's expeditions to Mongolia show that certain small Cretaceous mammals had characteristics which mark them as intermediate between the earlier and the more recent forms.[1]

The Cenozoic, or Era of Mammals

After the Mesozoic comes the Cenozoic or Era of "new life", which has lasted perhaps 3,000,000 years thus far. It is divided into two chief periods, the Tertiary and the Quaternary. It is predominantly the Age of Mammals and is marked by what from our point of view is called a modernization of forms. The mammals, hitherto primitive and inconspicuous, appear in all the diverse forms and habitats which are characteristic of rodents, horses, mastodons, elephants, rhinoceroses, lions, mules, bats, sloths, monkeys, and men. One of the most notable features is the interlinked development of flowering plants, which yield concentrated foodstuffs, and of the mammals which feed upon them.

[1] These fossils are pictured in *The Literary Digest,* April 23, 1927.



(*Courtesy of American Museum of Natural History*)

DRAWING OF EXHIBIT INDICATING THE EVOLUTION OF THE HORSE

The Tertiary period is further subdivided into epochs —Eocene, Oligocene, Miocene, and Pliocene, which indicate roughly the increasing prevalence of modern fossils, those of the mollusks being taken as the index. Thus Eocene means the "dawn of the new", Oligocene "a few —more than one-fourth—new", Miocene "less than" one-half new, and Pliocene "more than" one-half new mollusks. These epochs seem to have been set off from one another by recurring periods of glaciation. The succession can be followed most vividly by observing the succession of fossil horses, particularly from the rocks of Western North America. The famous exhibit called "The Evolution of the Horse" (see illustration) has been called "the edition *de luxe* of evolution"; it shows a progressive series of fossil skulls, leg bones, and teeth from specimens beginning with the "Eohippus", about as large as a fox, and continuing up to the modern horse. The indications are that when Miocene aridity diminished the shrubby herbaceous plants and promoted a wide expansion of the harsher grasses, containing more silica, the teeth of the horses became longer and harder, while at the same time by recession of the side-toes the single-toed hoof began to appear as an adaptation to life in the open plains where speed was essential for escape from enemies.

In the Tertiary period there are also significant data concerning the evolution of apes. At the beginning there are indications of tree shrews and lemur-like forms. In the lower Oligocene beds of Egypt fossilized forms have been discovered which seem to combine the characteristics of the primitive "tarsioids" and the later anthropoids (apes which are more like man), and may have been an-

cestral to the forms which we now find.[1] Some one has pointed out that the fact that fossil remains of apes are comparatively rare may be due to the increasing cleverness of these animals, which were not often caught in such situations as those in which fossils form. It is fairly well established that among the existing forms both in structure and function there is in general a more or less orderly progression from tree shrew to lemur and to monkey, thence to gibbon, orang, chimpanzee, and gorilla. The sequence is not unilinear, and no clear indication can be given of the ancestral relationships of these forms. The comparative anatomists surveying the existing species are in the position of a man who has in his hands some but not all of the ends of the thread of an exceedingly tangled skein which he is trying to unravel.

The Rise of Man

The problem of supreme importance for biological evolutionism is that of the origin of man. Here again there is no clear evidence, and such theories as have been put forward have been inferences based upon exceedingly fragmentary data. Judging from such succession of fossils as we have indicated, and in accordance with the arguments mentioned in Chapter V, the evolutionists have maintained that man is derived either from the anthropoid apes or from certain at present unknown ape-like ancestors. It has been supposed, for instance, that when in the course of the Himalayan uplift Pliocene aridity detached some of the hitherto widespread forests and thus isolated the mammals, it became necessary for the primates to leave the trees and, like the horses, adapt

[1] J. W. Gregory in F. Mason, ed., *Creation by Evolution,* p. 288f.

themselves for life on the plains. Man seems to be distinguished from the apes principally in the degree of complexity of the nervous connections which can be made in his brain, and it is possible that life in the plains, with its requirements of alertness and quick responses, may have promoted just these favorable variations.

The earliest so-called human remain, which may be sub-human, but at any rate is the most interesting fossil in the world, is the so-called *Pithecanthropus erectus*, or "erect ape-man", discovered in a Pliocene bed in Java in 1891 by Dr. Eugene Dubois, now of Haarlem, Holland. The remains consist of a skull cap, femur and three teeth. The skull cap is in some respects intermediate between ape and man; it is noticeably small as compared with man; the slope of the forehead is low; there are prominent ridges over the eyebrows; and the brain capacity is only about two-thirds that of the skull of a normal man. The femur is straight, indicating that the *Pithecanthropus*, unlike some later human forms, walked erect. The age of the fossil is roughly estimated at 500,000 years.

The portions of a skull and lower jaw known as the Piltdown fragments, from the place of their discovery in England, blend ape-like and human characteristics. The chin, jaw, and front teeth are not like what we know as human, but the forehead and brain cavity are more like ours.

The Quaternary period is divided into the Pleistocene Age, containing "most new" mollusks, and the "recent" age. From the Pleistocene comes the next item in the scanty sequence of sub-human and human fossil remains. This is the famous "Heidelberg jaw", discovered in 1907

imbedded in river sand more than 70 feet below the surface—a startling indication of its age, perhaps 400,000 years. Its most striking characteristics are the "pointless" chin and the heavy bones, and wide arch, much heavier and wider than in a modern human jaw. There has not been any serious doubt that the Heidelberg jaw is a human remain, although after it comes a long gap, so far as indications of the evolution of man are concerned. Nothing of further significance appears until we come to the so-called Gibraltar skull, discovered in 1848 and now, when compared to many other remains since discovered, known to belong to the "Neanderthal race". The race is named from a similar skull discovered near Bonn, Germany. Several more or less complete skeletons have been found at various places in Europe. The Neanderthal peoples apparently belong in a period beginning about 100,000 and ending about 25,000 years ago. The skulls are medium sized, with low foreheads and prominent brow ridges. The leg bones indicate that these men, unlike the far away *Pithecanthropus*, walked with knees bent. The race seems to have inhabited rock shelters and caves and to have lived by hunting and fishing. Some of the bones give traces of swollen joints, leading us to suppose that life in the damp sub-glacial climates was made miserable by rheumatism and kindred afflictions. The products of Neanderthal industry, including arrow heads, stone hatchets, etc., show different degrees of skill and are identified as belonging to different epochs of paleolithic or "old stone" culture. The epochs are named from the localities, chiefly in France, where the original or most characteristic remains have been found. Among the "finds" are Chellean, Acheulean,

Solutrian, and Mousterian remains, exhibiting different degrees of skill in workmanship. Some of the Neanderthal skeletons make it appear that ceremonial burial was practiced and may indicate the rudiments of beliefs in life after death.

The Aurignacian and Magdalenian remains are much more elaborate and artistic, and are usually ascribed to the superior Cro-Magnon race which seems to have displaced the Neanderthal peoples of Europe about 25,000 years ago, while the climate was still sub-glacial. The stone implements even of these later peoples were unpolished and hence are still paleolithic. To the "upper Paleolithic", and especially, to the Magdalenian epoch belong the famous carvings, drawings, and paintings in the caves of southern France and northern Spain. With marvelous realism and fidelity to outline, they show primitive man as contemporary with the bison, rhinoceros, cave-bear, mammoth, horse, reindeer, etc., in southwestern Europe.

The neolithic races, using "new stone", *i.e.*, polished stone implements, are intermediate between the paleolithic and those peoples which by reason of their written records belong not to prehistory but to history. By some authorities the time during which man has developed and come increasingly to dominate the other species is called the Psychozoic Era—but that time has thus far been relatively so short that it seems hardly appropriate to dignify it by the name of an Era.

The Pageantry of Life

Such is the picture of the succession of species, as one after another of them appears, rises to dominance, and

disappears. In depicting the process Lull uses the phrase "The Pulse of Life", indicating that in one geological period after another some change in the natural conditions has quickened the life process, just as the pulse of a man sometimes exhibits accelerations due to changes in his adjustment to his environment. This metaphor is perhaps not the best available, since it is not precisely the pulse, but accelerations of the pulse, with which Lull is concerned. More adequate is Woodward's title, "The Progression of Life on Earth"; but this gives the impression of progress and seems to overlook the many divergent and retrogressive trends among the living organisms. Perhaps a better metaphor than either of these would be that of a pageant, composed of many elements, some of them interacting with others, all gradually moving across a stage—acting their several parts, some fulfilling their functions well and others perhaps acquitting themselves poorly, but all sooner or later passing out into the wings.

Before concluding this chapter a few general observations will be in place. With reference to the picture as above presented, it should be noted that, impressive as it may be, it brings no proof of evolution. A creationist could use the same picture, adding the creative agent or power, perhaps as a veritable *deus ex machina*, a god kept in the background until needed to help in a difficulty. The fact that the fossils and living species can be arranged in these series may suggest, but does not at all make it necessary to suppose that the later have arisen from the earlier by the operation of inherent causes. The great argument for inherent causes, as we said, is not

from abundance of evidence, but from economy of inference.

In looking over the sequences of living forms, it is important to note that evolution, if it occurs, is not necessarily universal at any given stage. It is sometimes advanced as an argument against evolutionism that fossils discovered in rocks millions of years old are so far as any one can discern, morphologically indistinguishable from present-day living forms. For instance, the creationists avail themselves of the fact that Wheeler, using a time-scale different from the ones indicated above, says certain ants preserved in amber 65,000,000 years old are practically identical with present-day forms. But evolutionism has never maintained that all the organisms of a given species were modified into or gave rise to organisms of new species; presumably at first it is only a few organisms which are involved in any such change. The fact that countless organisms persist virtually unmodified may tell against the Darwinian view that only the fittest survive, although in order to establish the point very careful studies of environmental conditions would need to be made. But at all events the fact that unmodified organisms persist does not avail as an argument against the occurrence of an evolutionary process.

Another general consideration which appears when one surveys the wide range of data is most significant for any philosophy of history. Unless there is some distortion in the picture, due to the particular position we occupy or the angle from which we see it all, we must say that the process exhibits startling indications of speeding up. The Archæan, for instance, is longer in time than the combined range of all the Eras which have succeeded it. The

same may be said, if not for the Proterozoic, at any rate for the Palæozoic, and also for the Mesozoic Era. The Neanderthal race or races dominated Europe during a period far longer than the time which has elapsed since their disappearance. The Paleolithic epochs were longer than the Neolithic, the prehistoric than the historic. Even within the range of the historic record, something of the kind may be traced; it is a familiar statement that civilization has advanced further in the last century or so than in a much longer period just preceding. Even within the last decade, the appearance of such miracles as radio and some prospect of the outlawry of war seem to be fresh examples of the general principle.

For untold ages the pageant moved with a majestic slowness; but the plot is becoming more complicated and the tempo of the piece seems to be faster as it swings along.

CHAPTER VII

THE EVOLUTION OF NERVOUS SYSTEMS AND MINDS

Evolution in Biology and in Neuropsychology

We have repeatedly called attention to the fact that evolution is no unilinear process. The data exhibit countless interlocking features which the serial arrangements are inadequate to represent. This is true whether the serial arrangements are actually encountered in nature or are imposed by the only treatments of which our piecemeal minds are capable. It seems to be beyond doubt that at least locally, here in the earth, some evolution of matter has preceded the evolution of living organisms, and that some evolution of the latter has preceded that of nervous systems and minds. But even with all this serial order, we may assume that the evolving nervous systems have not merely conformed to, but have modified the organisms, and by differentiations have led to rearrangements and adaptations of organismic structures. Certainly the coelenterates have one type of nervous system, of which the annelids exhibit modifications, and these modifications appear to be carried further in the fishes, amphibia, reptiles, birds, and mammals. And even if in all these cases the nervous system has followed rather than led, its influence appears conspicuously in the case of man and in the great drawing-away of human

from animal societies. Here, particularly, the interrelations are so numerous that any attempt to separate biological and neuropsychological evolution must be in some respects artificial. Thus our account of the evolution of living organisms has already involved the evolution of many types of nervous systems and minds. Nevertheless there appear to be processes of evolution quite characteristic of nervous systems and minds; to these we now turn for a more detailed examination.

Theories of the Relations of Mind and Body

Among the many questions which arise when such an attempt is made, prominence must first be given to the very old problem known as the "mind-body problem". Especially since the days of Descartes (1596-1650), philosophers and scientists have argued about the nature and relations of mind and body, or mind and brain; we may say briefly that four chief types of answer have been given for it. According to the view of *interactionism*, or animism, mind and body are essentially different —for instance, body is material, while mind is perhaps "spiritual"—but each works upon the other; the two interact. According to *parallelism*, the two are essentially different, but do not interact; they run along "concomitantly", forever parallel, synchronized somewhat like some of the "talking movies". According to *epiphenomenalism* (from the Greek words for "upon" and "appearance"), mind "appears upon" body as a kind of temporary excrescence, or like spray on the crest of a wave. According to the *"double aspect"* theory, the two are merely different aspects of one underlying reality. More recent is the *"double language"* theory, that the

two are merely different ways of referring verbally to the same thing.

In discussing "the evolution of nervous systems and minds", and in joining together as we do the two parts of the word "neuropsychological", we do not necessarily commit ourselves to any of these theories of the ultimate origin or nature of either body or mind. The general view of evolution is broad enough to include, with more or less consistency, any or all of the classical theories, although moderate evolutionists would incline to interactionism or parallelism, while extreme evolutionists would favor epiphenomenalism and the double language theory. Either moderate or extreme evolutionists might regard body and mind as aspects of some underlying reality. All that is required for evolutionism is that the data of neurology and the data of psychology alike should be construed as indicating the operation of inherent causes.

Mind As Nervous System At Work

Our own assumption in this chapter, made for the sake of simplicity and directness, is that a mind is a nervous system at work and that nervous system and mind are related as structure and process. The relation between neurology and psychology is thus comparable to that between the sciences of anatomy, or morphology, dealing with the structures of living organisms, and physiology, dealing with the processes characteristic of those structures. Our attempt is, as will be seen, to study structures and processes together. But it should be borne in mind that our assumption, indicated by the use of the word "neuropsychology", is not necessary to all doctrines

of evolutionism, and that anything in this chapter which is said in accordance with this assumption could be restated in the phraseology of the other theories. A view more animistic would, however, belong to moderate rather than to extreme evolutionism.

Principles of Neuropsychological Development: Conduction

The data on neuropsychological development are encountered throughout a wide range of animal groups. We may sum up the nervous organization found throughout this wide range by tracing certain processes which are so general that they may be termed principles of nervous development. Of these the simplest appears to be that (1) *nervous structures exhibit certain processes of conduction of disturbances or impulses.* The statement at once needs qualification in several respects.

The disturbances are ordinarily set up by stimuli from outside acting upon the "receptors" of an organism, for example its sense organs, and the disturbances usually issue in some discharge of energy from the "effectors" of the organism; for example, its muscles. But just what structures in so-called sense organs and muscles are to be reckoned as parts of the nervous system is a matter of detail and definition; whatever be the answer for different species and different organs or muscles, the work of the nervous system must be studied along with that of receptors and effectors. The nervous system always performs a function of conduction, whether the system be said to include the receptors and effectors or merely to run between them.

The physiological basis for the development of con-

ducting paths in organisms seems to be afforded by what C. M. Child of Chicago calls "metabolic gradients"—*i.e.*, differences in rate of metabolism in successive cells or parts of cells in series or along an arc. Child and his co-workers have detected such gradients in unicellular organisms, as well as in plants and animals. Generally speaking, a receptor will exhibit a high rate of metabolism, and, other things being equal, this initial rate diminishes as the impulse is communicated to one cell after another along the gradient.

There seem to be indisputable evidences of conduction in organisms which are usually said to be without nervous systems; the cases are such as to raise the question as to just what constitutes nervous conduction and what does not. In recent years there have been at least two types of investigation tending toward revision of the earlier opinions. C. A. Kofoid and his associates in California have shown that even unicellular organisms possess certain fibrils which are called "neurofibrils", along which impulses pass, and thus that nervous or quasi-nervous systems are not confined to the multicellular groups. Again, the East Indian scientist Dr. J. C. Bose has long maintained, on the basis of experiments with very delicate instruments of his own invention, that plants exhibit processes of conduction of impulse which entitle them to be classed with the organisms possessing nervous systems. There are formidable questions here, not so much concerning the experimental results, which have attained some recognition, but concerning the definition and delimitation of the meaning of the term "nervous".

In the sponges among the lower organisms there are

well defined cases of local conduction, which Parker calls "neuroid conduction", by means of specialized cells which, however, are not true nervous cells. But the activities of such organisms, compared with those of other animals, are noticeably uncoördinated and slower. In fact, what the nervous system accomplishes can best be appreciated by studying one of these organisms where it is lacking. The sponge, equipped with only local excitation arcs, lives upon minute organisms which it extracts from the water passing through its body-cavity. The water is whipped along by the action of the flagellated cells which line the cavity. The opening where the water enters is called the sphincter. When the sphincter is open the flagellated cells whip the water along and all goes well; but if by reason of some local condition the sphincter closes, the whipping continues just the same, even though it is just that much waste of energy. In other words, the activities of the sponge are not coördinated; its organization lacks a system of quick adjustors which will sort out and combine different impulses, with resultant actions which are harmonious, efficient, and beneficial for the whole organism.

Coördination

This brings us to our second principle of nervous development, namely that (2) *nervous systems are coördinators of the various stimuli and responses of an organism.* This is a very general principle; every other principle which we shall discuss is in a way an elaboration of one or another of its particular applications and details.

It must, however, be added at once that nervous sys-

tems, in the usual sense of that term, are only one of the means of coördination possessed by organisms. There appear to be, for one thing, purely physiological means of coördination. Thus the more complex multicellular organisms are found to possess coördinating systems of ductless glands, the so-called endocrine systems, which discharge specific chemical substances, hormones or chalones, into the blood stream and thereby activate or depress one or several distant organs of the body. The ductless glands thus exercise profound effects upon the growth and development of the organism, apparently without any direct dependence upon the nervous system. The recognition of the coördinations exercised by the system of glands has done a great deal to furnish a new alignment for the whole problem of body and mind.

The function of the nervous system when it develops seems to be to furnish a more rapid and efficient coördination of the activities of the organism than is afforded by the more purely physiological mechanisms. Certainly a step toward better coördination is seen in the sea-anemone where there are a large number of peripheral sensory cells with deep branching ends connecting more or less directly with the muscles. This is what Parker calls a "receptor-effector system"; in the simplest cases none of the cells involved is a specifically nervous cell.

What Parker calls "protoneuronic conduction" appears when true nervous cells rather than mere fibrils are found as adjustors between receptors and effectors—a structure characteristic of the higher coelenterates. These cells are usually interconnected by fine fibrils or branches and so constitute a nerve-net capable of connecting all parts of the body. Conduction in nerve-nets is

often said to be diffuse, in all directions at once, and coördinations are vague and loose, showing lack of discrimination or specialization in response. There is, however, evidence that even in organisms equipped with nerve-nets a more selective and specialized conduction, and hence coördination, between particular receptors, effectors, and adjustors is possible.

Reflex-Arcs and Reflexes

This brings us to our third principle, which is that (3) *nervous conduction tends to pass from a given receptor via one or more particular nerve cells or neurons to a particular effector or group of effectors; such a definite path or string of cells is called a reflex-arc.* The word is used loosely, to indicate nervous structures of various degrees of complexity, and even to include non-nervous arcs. Strictly speaking, a reflex-arc should be distinguished from a reflex; the former is a structure, the latter its characteristic process. As development with its continual differentiations proceeds the organs of sensation and response become more and more complicated, varying all the way from the pigment spot of the jelly fish to the human eye, and from the cilia of the coelenterate to the human arm. But as was said above, a reflex-arc must not be considered as if it were dissected away from its receptor and effector, no matter how complicated these may be. Some of the more complicated later reflex-arcs may be designated as "patterns" without any essential alteration of the principles involved.

The most familiar receptors and effectors lie on the exterior surface of the body; but it must not be forgotten that after the infolding of the ectoderm and development

of the body cavity which marks the coelenterates many receptors and effectors lie in the interior, supplying the joints and muscles there, as well as the various organs and glands.

The coördination between receptors and effectors exhibits a complication when the action of a given effector modifies or removes a former stimulus and provides a new stimulus for a receptor, which thereupon excites an appropriate effector, and so on. Thus reflexes become "circular", and in the incessant activity of the organism circular or "chain" reflexes are very common.

Progressive Centralization

Several important steps in nervous development appear in the animals whose bodily structure exhibits sections, or segments similar to one another, especially when the segments are ring-like, as in the annelids. These steps may be summed up in the important principle that (4) *nervous structures tend toward concentration, and the functions of coördination tend to be exercised in and through these central structures.* To begin with, each segment typically has its own reflex mechanism, taking care of stimuli and responses within it. Some of these animals, for example the star-fish, are "radially symmetrical", somewhat like a wheel and its spokes. In such animals there are nervous strands for each segment, with a central ring in the position corresponding to the hub of the wheel. Other animals are elongated with segmental structures repeated along the length of the body, as in worms. Here there are not merely segmental reflexes, functioning within each segment, but also super-segmental reflexes, connecting more than one segment

and requiring nervous structures of greater length. This promotes the nervous structures found in the "ladder" type of nervous system in the worms, in the notochord of primitive vertebrates, and in the spinal cord of the later vertebrates. In the annelids, too, there are some traces of a system of coördination and unified action of various organs and glands—the kind of system which in us constitutes the so-called autonomic system and is most familiar from that division of it called the sympathetic system. Moreover, a relatively long animal will tend to swim or crawl in a forward direction, along the longitudinal axis of the body, and will encounter the environment most critically at its forward end. This leads in the worms to a concentration of nervous tissue in "ganglia" at the forward end near the mouth or æsophagus, and to the rudiments of the structure which we know as the brain.

The developments of nervous structure found in brains of the higher animals are often baffling in their complexity, but they can all be reduced in principle to so many intermediate links inserted in, or superposed upon, the super-segmental reflexes and ganglia of animals like the worms. Thus the neopallium of the reptilian brain, the cerebellum of birds, and the cerebral cortex of the primates and man are more and more complex structures, with increasingly manifold possibilities of conduction and coördination.

Shunting of Impulses At Synapses

Beginning at or near the stage of development represented in the worms we find that (5) *conduction along definite paths and coördination of specific portions of*

the body is accomplished by means of the making and breaking of connections between various nerve-cells in the reflex-arcs. In the earthworm, for instance, there are receptors in the skin with sensory conductors, *i.e.*, fibres leading away from them; "adjustors" in the ganglia, and motor conductors or fibres leading away from them; and, finally, effectors or muscles. But the connections are such that many sensory fibres discharge into a ganglion and many motor fibres leave it, so that very many different combinations of stimuli and responses become possible. Obviously it would be no advantage to the earthworm to have all these paths functioning at once, since many of them lead to responses which are precise opposites of one another and their simultaneous discharge would result only in confusion.

Such confusion is avoided by an arrangement which seems to interpose barriers at the ends of the nerve-cells which make up the reflex-arcs or paths, and a making and breaking of connections at these barriers somewhat similar to the making and breaking of connections on a telephone switchboard or in a railroad yard. The barriers are known as synaptic barriers and the connections as synaptic connections or synapses. There has been in the past some question as to whether actual contact occurs between the fibres of the different cells in an arc. The trend of opinion seems to be that whereas in the pre-synaptic or protoneuronic type of conduction there is such contact (called anastosmosis), in the synaptic reflexes the receiving fibres of one cell, which are called dendrites, merely come quite near the transmitting fibres of another, called axons. At any rate an impulse from any receptor *A* may theoretically pass along the fibres

of neurons *a, b, etc.*, . . . and at length activate effectors *X, Y,* or *Z.* But by reason of conditions at the synapses, neurons *x* and *y*, leading to effectors *X* and *Y*, may be shut off for that impulse, and only neuron *z*, conducting to effector *Z*, be open.

Just what it is that determines along what path a given impulse will pass is not altogether known. Doubtless the intensity of the stimulus, the rate of transmission, differences of electrical potential at the synapse, the colloidal properties of the surface concerned, the frequency with which similar impulses have passed that way before, and the general condition of the organism in its environment, all have something to do with it. At any rate some impulses are shunted over to produce some effects, while others are prevented, at least for the time being, from producing those effects. If a response once made is found successful, it is likely to be repeated and, as the phrase goes, "stamped in". When confronted with a novel situation some animals at first exhibit random responses, as when a rat put into a maze for the first time runs hither and thither, trying all possible ways out. When at length such an animal has once hit upon the appropriate response this response tends to become habitual, and the result can be obtained in future trials without so many useless movements. The animal is then said to have learned the proper response by "trial and error"—or, more aptly, "fumble and success".

The very important process whereby some impulses are checked or sidetracked by others is called *inhibition.* Many sets of muscles in the animal body are directly opposed to one another and antagonistic—for example, the muscles which bend and which extend the leg. When

one set of antagonistic muscles is working the opposite set is inhibited; and, in general any given activity carries with it the inhibition of activities out of harmony with it.

What Is "Consciousness"?

It is to the process of inhibition, and the conflict of impulses or tendencies which it involves, that some investigators trace what they or others regard as perhaps the most distinctive property of mind—namely, consciousness. The term "consciousness" is perhaps best left undefined, at least as regards its precise boundaries. It is as hard to determine these as it is to tell the precise point at which one drops off to sleep. Moreover, in order to define consciousness one must be conscious; this makes it permissible to leave the sense of the term to be felt rather than stated. If one does not feel it already, any attempt to describe it or state what it is may be futile. This way of dealing with the problem of consciousness is open to several different treatments. On the one hand, the extreme behaviorists attempt to understand the human mind by the use of the same laboratory methods as they are obliged to use for their experiments upon animals. In experiments upon animals they must of course rely upon "objective" responses, without access to the detail of what the animal might possibly regard as the course or flow of its intimate experience. Accordingly, the extreme behaviorists distrust the introspective methods of the older studies in human psychology and maintain that the mere subjectively experienced feeling of an individual about consciousness and his reports of it have no scientific status. On the other hand, the philosophers of the school known as epistemological idealists (from epistemology, or theory of knowledge, and ideal-

ism, here meaning emphasis on mind) maintain that since consciousness is indispensable for our knowledge of the world and ineradicable from the world as we know it, therefore it must be essential and the whole world must be an item in a consciousness or mind. But neither of these extreme views is necessarily a part of evolutionism.

The problem of evolutionism is not so much to define consciousness or to assign its importance, but to account for its development; and the evolutionists, as we have seen, are here divided between the moderate and extreme views. Those behaviorists who entertain the notion of consciousness at all trace its origin to the operation of inherent causes; consciousness is a kind of friction of opposing or mutually inhibiting tendencies. Opposed to such behaviorism or, historically, to such epiphenomenalism, is, as we saw, the position of animism, which regards consciousness as an intervening agent or property of an intervening agent such as mind or soul. They argue that consciousness is directly experienced as unique and different from any physical process, and that such a view is in better accord with the "higher life", especially as taught in various theological doctrines. Be all this as it may, it is fair enough to the evolutionists (except in the cases of certain idealists) to trace at least the dim rudimentary beginnings of consciousness to the beginning of inhibition and conflict in the nervous systems of some of these lower animals. Some of the behaviorists call consciousness a property of reflexes in combination.

Storing Up Past Experiences

The interposition of synaptic barriers along the reflex arcs makes more conspicuous than ever another important function of the central nervous system—namely that (6)

particularly in the synaptic type of organization, the central nervous structures serve as store-houses or reservoirs of energy which is available when released by appropriate stimuli and makes it possible for one reflex powerfully to reinforce another. Stimuli accordingly come more and more to act as triggers, and the energies and intensities of responses vary more and more from those of the stimuli which call them forth. This reservoir action of the central nervous system is important for several processes concerning which there has been a good deal of controversy among psychologists. Most investigators agree that the nervous system by a storage of residual effects in some way stores up "implicit responses", which some are willing to call images, and that such residual effects are important for processes of association and memory. But in these processes as we know them in ourselves other elements, as we shall see, have entered, so that the mere fact of storage of energies affords only the rudiments of imagination or memory.

Importance of Perception At a Distance

The development of the nervous system shows another of its definitive steps when, in the animals of the grade of annelids and above, the forward segments begin to develop the sense organs characteristic of the head. We may put it as another general principle that (7) *all higher nervous development is based upon the functioning of the distance-receptors localized in the head.* Distance-receptors are receptors like eyes and ears, equipped to receive stimuli other than those of contact, coming from a distance. Their importance is shown by the fact that an organism not equipped with such receptors must

wait until it is actually struck by an enemy before it can respond, and by that time the response in very many cases must be too late. But an organism which, for instance, can see or hear the enemy coming at a distance has time to make preparations for the meeting, and it may be supposed that under such conditions many more of the final responses are successful. The same thing applies to the search for food; an animal which can see or smell food at a distance can go through whatever preparatory reactions are necessary before finally securing the food. Sherrington distinguishes between the precurrent, or preparatory, and consummatory, or final reaction of such a series. It is clear that in these precurrent-consummatory reactions we have very important units of organization; we may call them end-reaction complexes.

Such end-reaction complexes, where an object is held in view while certain preparatory adjustments are made in dealing with it, seem unmistakably to provide the rudiment and basis of the organizations we call purposes. We shall see later that in these organizations first words and then ideas may be substituted for actual distantly perceived objects; it needs only such substitutions to yield simple purposes such as are familiar to us. In the end-reaction complexes, accompanying and either reinforcing or inhibiting both preparatory and consummatory reactions, are reflexes involving the endocrine and autonomic systems, and evident to us in emotions.

More than one end-reaction complex may be in process of organization or expression at the same time, and there may be a marked conflict between them. Such a conflict, particularly if prolonged in time and involving some of the higher structures to be studied later, appears to con-

stitute the type of mental activity called will or volition. The mention of such a word calls up many questions and controversies concerning freedom, responsibility, etc. To some of them we shall return at a later point, noting here merely that the basis in nervous structures and processes for all these activities appears to lie in end-reaction complexes and their conflicts.

"Automatic" Activities

The adjustments here may be quite mechanical, in the sense that there is no conflict or conscious choice of reactions. Numbers of the so-called tropisms, instincts and automatisms are organized in this way. The line between these forms of behavior is difficult to draw with precision. A tropism is a reaction characteristic of an organism or species and apparently due to some combination of its reflex-arcs which is not varied according to circumstances, and not subject to the modification which we shall presently describe as "conditioning". A tropism need not even be nervous; an example of a non-nervous type is the "geotropism" exhibited by a plant when its roots push downward into the earth. An example of a tropism involving automatic action of the nervous system is seen when a moth flies into a candle-flame. Tropisms may be either positive, as the foregoing, or negative, as when an animal avoids the source of a stimulus instead of seeking it. The term "instinct" is variously defined; it may be regarded as a complex tropism, which, according to most psychologists, has been inherited by a given organism and is prearranged in the structure of the nervous system as this is reproduced in generation after generation. It ought to be noted that the controversies of

recent years about the hereditability of instincts are a little off the main line of problems of evolutionism; evolutionism would still be a problem, whether instincts were inherited in a species or phylum or were developed within the life-history of a given individual. The definition of automatisms is more or less bound up with that of consciousness; an automatism may be said to be any response which we do not consciously control.

Some More Inclusive Organizations

Tropisms, instincts, and automatisms are all reactions of various degrees of complexity, and all show somewhere that experience tends to be organized in units more inclusive than the reflex-arc. This fact has been made somewhat familiar because of the more or less loose use of the term "complex" in recent psychology. At this point in our discussion is a good place to note that the view of organization as a cardinal principle for any account of the processes of mind has received much impetus in recent years from the so-called *"Gestalt"* psychology. The German word is roughly translated "configuration", or "pattern". According to this psychology, under the leadership of Koehler, Koffka, and Wertheimer, it is possible by too much analysis to lose sight of the real data of psychology; the proper integral unit is not a reflex but a combination or complex of reflexes. Such combinations are observable in animal behavior when, for example, an ape confronted with a banana just out of reach and a stick on the floor of his cage sometimes straightway, without any preliminary random movements of trial and error or "fumble and success", makes the stick, as it were, complete the organization of the otherwise imper-

fectly organized response, and uses it to knock down the banana. This, according to Koehler, is learning by a process other than that of trial and error. It should be noted that probably some of the differences between the *Gestalt* psychologists and the behaviorists are due to the fact that most of the experiments performed by the two groups have been performed upon animals, which, like apes and rats, belong toward opposite ends of the animal scale.

According to the *Gestalt* school, these theories find especially fruitful application in human psychology. Our own tendencies to complete an otherwise incomplete organization are illustrated even in cases of simple perception, as when we perceive, let us say, five continuous radii successively inscribed as chords inside the circumference of a circle and, instead of thinking of the figure as one of five inscribed radii, think of it as an inscribed hexagon lacking one side. According to these psychologists, even comparatively simple perceptions are *Gestalten*; and the same principle with increasing complications applies throughout all mental life.

Distance receptors are important also in connection with the residual effects noted above. The stimuli coming from a distance are of such high importance for the preservation of the organisms that if there are any marked residual effects they tend to dominate memory and imagination, and are conspicuously available for processes of conditioning, to which we now come.

Processes of Substitution in Reflexes

It is particularly in end-reaction complexes which, as we saw, comprise elements furnished by the distance-re-

ceptors, together with whatever precurrent responses are appropriate to these, that we encounter another process of vast importance. This is seen in the fact that (8) *the nervous system of higher animals, by means of manifold synaptic connections, becomes capable of linkages and transfers between reflexes in the process called conditioning.* The classical work on conditioned reflexes was done by Pavlov of Leningrad, who by means of an instrument could measure the flow of saliva in the mouth of a dog. When the dog was fed, the saliva of course flowed. Pavlov then began sounding a metronome at feeding time, repeating the practice many times, and finally sounding the metronome without any feeding. But with the metronome used alone it was found that a flow of saliva was excited, somewhat as the normal flow was excited by the primary stimulus. The general principle here is that when two stimuli *A* and *B* have been associated in the production of a response *C*, even though *B* be merely accidental, after a suitable number of trials *B* may produce the result unaccompanied by *A*.

It should be noted in passing that all conditioning necessarily implies a kind of inhibition, inasmuch as when any new linkage is effected at least some of the responses appropriate to other unmodified stimuli tend to be cut off.

The whole process of conditioning may seem quite remote from anything important in our experience, but it furnishes a clue to the development of language and probably also of thinking. The language process requires consideration not merely of individual but also of social factors in the development we are surveying.

The Individual Mind and Society

In any account of the development of the individual, whether in mind or body, it is useless to attempt to consider the individual apart from the group, and in everything said thus far the existence of other individuals of the various groups may be said to have been presupposed. This is important enough to find recognition in another principle, namely that (9) *the reactions of one individual are often initiated and often in a sense completed by other individuals of the group.* Very early in the development of mind appears the essentially social reaction summed up under the term "language". Language may be either gestural or vocal, or both; if vocal, it may be inarticulate, as in a cry, or articulate, as in a sentence with parts of speech. The gesture or cry seems often to be only an additional response, a mere accompaniment or by-product of whatever the individual is doing; but even if this is its origin, it is perpetuated by its utility as a means of indicating that many actions of the individual are to be repeated or completed by other members of the group.

Sometimes mere repetition of a given action is enough. When a crow, for example, sees a hunter coming, the crow may respond to the stimulus by taking flight, and other crows of the flock may do the same. But of a flock of crows it is not necessary that every crow shall see the hunter coming; it is sufficient if a "sentinel crow" sees him and, taking flight, gives the alarm to the others. The others respond to the sound of alarm as well as to the actual sight of the hunter. In other cases, the leader of a group by a cry of command may use a language response as a substitute for a more overt response, leaving the

more overt response to be completed by the other members of the group, the followers. So a cry, at first superfluous, may, like stimulus *B* in our formula for conditioned reflexes, elicit a primary response. The process of conditioning appears most conspicuously in the case of men. Instead of responding to a real enemy, a man by means of a conditioned reflex can exhibit the appropriate response to a cry that has been even accidentally associated with the appearance of an enemy; and in general, words can secondarily come to evoke the responses which are primarily evoked by things.

The rounding out of an inarticulate cry into the articulate form familiar in a grammatical sentence may be accounted for in terms of progressive separation from the objects meant. For instance, if a man is in the presence of an enemy, it will probably not be necessary for him to use the word "enemy" in referring to the object meant; the *word* is evidently best adapted to use in the absence of the real object. Similarly, it is ordinarily not necessary to use any given verb while the action denoted by that verb is unquestionably and obviously in progress. The verb is used when the action is, one might say, absent, or defective, or for any reason in need of modification.

Relations of Language and Thinking

There has been a long discussion concerning the relations of language and thinking; in general, those who in their philosophies have emphasized the place and functions of mind in the world have been inclined to find some other origin for thinking than the ordinary process of language, and have regarded the flow of thought as

something other than language reactions. That thinking was merely a kind of reverberation of language mechanisms was the view of the early extreme behaviorists; it is now by behaviorists quite generally qualified in the statement that thinking is a reverberation or residual effect in other bodily mechanisms as well as in those laryngeal mechanisms immediately involved in cries or articulate language. It seems clearest to say that (10) *by a further conditioning of implicit responses, including images and language responses, which were primarily elicited by external objects or other individuals in the group, an inner play of images or inner language develops in certain individuals and is called ideation.* Ideation is thus regarded as a process among residual responses in a nervous system, whether these are predominantly individual, as are images, or social, as are language-responses. Sometimes the whole process has marked reference to an end in view, in which case the ideation is a kind of preliminary rehearsal of an overt response. It is not at all necessary that all thinking should be recognized either as images or as articulate language; it may be in a "shorthand", or, as one perhaps should say, a "shortmind", quite unrecognizable until one has unearthed many long-hidden clues.

All this accounts, if at all, only for the simplest cases of ideation, such as probably characterize some of the higher animals, but does not account for those more mysterious processes which we distinguish as reasoning and ordinarily consider to be confined to the human race as distinct from the higher animals. The step to reasoning seems to occur when an available mechanism becomes still more complex, and we have the processes of abstrac-

tion and generalization. The process of abstraction is not so difficult; it may be regarded as another case of a conditioned reflex. Instead of responding to a thing such as a tree, one responds to a particular part of the tree, such as a limb, or to a particular quality of the tree, such as green, or to words or to ideas corresponding to these or associated with them. Various degrees of abstraction are possible, in which the association becomes more and more remote. Some of the more remote associations give us metaphors, as when we speak of the greenness of a freshman. Inseparable from the process of abstraction is that of generalization; the greenness abstracted from the tree or the freshman refuses, as it were, to be confined any longer, but becomes indefinite in its reference; it is "simply greenness", or "greenness in general". This is often called a universal, but, properly speaking, the notion of a universal implies somewhere the idea expressed in the word "all" as opposed to "some". Thus "greenness" is a generalization, but "all greenness" is a universal.

The Organization of Sentiments, Values, and Ideals

(11) *Under the domination of images and ideas, the end-reaction complexes tend to develop into more elaborate organizations called sentiments or values.* As distinguished from a mere end-reaction complex, where the object dealt with in the consummatory reaction may be all the time perceived by the distance-receptor, a sentiment is an organization in which the consummating object or activity is more remote, and in the attainment of which there is often a succession or hierarchy of end-reaction complexes, each serving as a means to the one following. The best example of a sentiment, although it

is one of the most elaborate, is the sentiment of love. It may not be out of place to indicate a distinction between a sentiment and an attitude often called by that name but really better described by the word sentimentality. A sentiment or a number of sentiments are perfectly normal organizations of one's reactions. Without such organizations one could not be human; when one studies the behavior of a dog waiting for its master, it may be doubted whether without sentiments one could even be classed as a higher animal. Sentimentality, where it occurs, is the result of an exaggeration or misdirection of reactions properly belonging in a sentiment.

The line between sentiments and values is never drawn precisely, but usually a value is, of the two, dominated by a more abstract or general idea. An example of a value might then be "justice" or "international peace". An ideal is a value considered to be rather remote of fulfilment and marked, actually or potentially, with a considerable measure of social approval.

Thus, we might say, do organisms develop nervous systems and minds, and thus do men come gradually to serve ideals. But if this is said, something ought to be added concerning one or two even more inclusive totalities or organizations.

Selves and Personalities

It must have been evident, at least since the stage represented by the nerve-nets of the coelenterates, that the whole nervous system of the individual serves as the matrix for whatever reflex-arcs, synapses, conditionings, end-reaction complexes, etc., we have been considering. We may therefore add as a final principle that (12) *the*

totality of an experience of an individual may be called his self or personality, and the relations to it of the structures and processes just considered may be studied in terms either of integration or of differentiation. In one sense the self or personality, since it includes all the foregoing structures and processes, may be said to be a combination or integration of them; in another sense one may say that the structures and processes are just so many elements or differentiated parts of the totality. For a philosophy of evolutionism, either of these statements might hold; it would probably be best to take them both, in order more completely to deal with the many relations evident in the data.

The terms "self" and "personality", as well as the older term "ego", are used with some confusion and with many differences of meaning. Certain pathological cases of "dissociation" make it clear that in an individual large groups of reactions may become, so to speak, segregated and may set up as different selves in "multiple personality". Normally there is always a measure of such segregation in any complex and varied individual history; the difference between a man's "office self" and his "home self" is sometimes quite appalling. But ordinarily the various "selves" are at least federated, and get along by a kind of "gentlemen's agreement", even if they are not integrated into the unity of one harmonious personality dominated by a single commanding ideal.

One of the most subtle and difficult points in all psychology has to do with the "self". It is in connection with what we at least *call* the self that problems of freedom, in the practical if not the theoretical sense, become acute. When we study the situation, we may find that

what we call the "self" is only a part of our experience, although it is a particularly well-organized part, and that in the act of "willing", this part is pitted against another part or parts of our experience. There seems to be a cleft or split within each of us, and the so-called "self" is only a part of the whole which is split. Moreover, we have to study ourselves, and thus we are somehow both the subjects and the objects, the knowers and the known. In fact, both the knower and the known seem to be selves, differentiated within the total unit which we call individual personality. And, when we come to think of it, particularly with allowance for the views of the social psychologists, we find that any individual personality, too, is a differentiation, a knot in the network of society. No view of one's personality which is obtained by one's own self seems to be complete; it needs also the check and criterion of an outsider's judgment; we need to see ourselves from within as well as we can, but we need also to see ourselves as others see us.

Perhaps we might go on to see in society, where numbers of individual personalities communicate and cooperate, a still larger neuropsychological structure which might be called the "social mind", or the "common will". Certainly such a phrase as "public opinion" or "public sentiment" must be assigned some weight and importance, although if we are to use the term "mind" on this scale it must be admitted that its pluralistic or manifold structural basis is quite different from that of mind in the individual.

Conclusion

The great thing to note in connection with evolutionism here is that neuropsychological structures and processes

show integrations and differentiations, and that development, although by no means unilinear, and although the account of it is beset by many special difficulties, may nevertheless be sketched out. Here again, no one can exclude all possibility of the operation of intervening causes. We should note in passing that of course every stimulus from outside acts upon mind as an intervening cause, but these, being accounted "natural", are not emphasized and are not counted against a theory of evolution. No one can be sure that God or some other supernatural agent has not intervened to make the neuropsychological structures and processes of the earthworm different from those of the coelenterate, or the sentiments of the man different from those of the same individual when he was a child. But it appears here as elsewhere, that while intervening causes cannot be ruled out as impossible, the more economical operation of inherent causes may be plausibly inferred.

CHAPTER VIII

THE EVOLUTION OF CULTURES

The Evolution of Society Includes That of Bodies and Minds

We must repeat once more that evolution is not unilinear, that it involves not merely integration but also differentiation, and that it has to take account of the interactions of many different structures in a complex interlocking of processes. All this becomes most evident when we consider the evolution of cultures. By the term "cultures" we shall mean the data commonly studied in anthropology, economics, politics, ethics, art, and religion, as these are developed in various human societies.

Let us first review for a moment some of the developments we have already studied, which now appear as aspects or enter in this most complex development of all. In the first place we may take for granted that there would be no culture without biological organisms. But biological organisms cannot adequately be studied merely as loose aggregates of individuals; organisms as we saw are themselves organized into more and more inclusive groups, such as hordes, families, tribes, and nations. But such groups are not fully described if they are treated merely biologically; they exhibit varying degrees of culture, and the nation and whatever still more inclusive groups succeed it in the series are preëminently cultured

units. Apparently then such "super-organisms" among the human biological groups afford the structural basis, or exhibit the structural aspect, of the evolution of cultures.

Again, a culture is conspicuously an achievement of mind, and, particularly if it is advanced, involves practically everything which we saw in the preceding chapter to characterize that evolution. Cultures presuppose nervous systems which exhibit the types of organization seen in sentiments, values, selves, and personalities; the description of a culture is the description of the objects and ideas with reference to which these neuropsychological organizations are achieved. The processes which together we call mind seem to permeate or penetrate the various biological groups with the results which we call cultures. If we regard biological evolution as essentially prior to neuropsychological, we have in the work of mind in the development of cultures another case of evolution by differentiation.

It will be evident at once that all human pursuits in economics, politics, ethics, art, and religion overlap, and frequently involve one another. Certainly any attempt to picture the development of all of them together as unilinear would be absurd; it is at best rather arbitrary and artificial to consider the development of any one of them in this way. But even though we must reckon with the dimness of outline which is characteristic of a composite photograph, certain main features of development can usually be distinguished; and certainly, if we are to describe such complex processes at all, line must follow line and precept follow precept; we can take only one subject and only one sentence at a time, indicating the

mutual interactions of the great structures and processes as best we can.

Evolution in Economics

One of the primary activities which has issued in the forms familiar to us in civilization is the activity of procuring food, or getting a living; the whole complex development of these activities is summed up in the term economics. All living organisms must face the problem of food-supply; failure to solve it means speedy extinction. In the insect societies we observe conspicuous examples of one of the main forms of social differentiation which has been of immense importance in all economic evolution, namely the differentiation known as division of labor. There are, as is well known, worker ants, soldier ants, etc. Division of labor is, like almost everything else, carried much further in human societies; the main lines seem to be those marking off the gatherers or producers of any given goods, and the consumers of those goods, with the addition, in highly complex societies, of "middle-men" or distributors. But in any such statement it must always be understood that in a healthy society all are gatherers or producers of some sorts of goods, and all are in some respects consumers. Possibly in a more restricted sense all are distributors, too, but the point is not so important.

The fact that there must be gatherers as well as producers of goods is often overlooked, but furnishes the basis of whatever justification there is for the economic organization known as capitalism. The great question here is not whether there should be capital, since capital, in the sense of accumulated and concentrated goods, is

certainly indispensable for any large economic advance. The question is, rather, who should hold the capital and control it—private individuals, working perhaps under little restraint for more or less private ends, or more highly socialized organizations, whether political or non-political, which might try to administer the accumulated capital for more highly socialized purposes. The former arrangement goes by the name individualism, the latter socialism.

The question of capitalism versus one or another form of socialism comes into a discussion of evolutionism when one recalls the origins of capitalism. At first the stronger individuals, like the ancient conquerors, were ruthless in their arbitrary disposition of whatever life or goods fell into their hands; it was customary, for example, for a captured city to be sacked and its inhabitants put to the sword. Then came the step characterized by the retention of captives as slaves, reckoned along with other goods among the chattels of the conquerors. In mediæval Europe and in Russia well into the nineteenth century the feudal system was a step beyond this; the lower classes were not exactly chattels, but as serfs they were bound to the land and obliged to serve the lords of the manors. A variant of this was the apprentice system in the towns, where apprentices were bound over to masters for terms of years. The emancipation of slaves and serfs, now almost universal throughout the world, has been succeeded by the so-called "wage system" where laborers or employees, who for the most part do not control the machinery of production or accumulation, "hire out" for wages or salaries to those who do control these things. One of the questions for any present-day discus-

sion of economic evolution is whether the "next step" is to be a socialization of industry with further curbs, or even the abolition of private capital (the kind of thing attempted in the first years of the soviet government in Russia), or whether the way of advance lies in recognition of the interdependence of capital and labor and the improvement of relations between them. Examples of movements in the direction last-named are various kinds of "welfare work", collective bargaining, profit-sharing plans, representation of workers upon directorates, and in some cases the gradual substitution of coöperative ownership for the older system. In this way all tend to become accumulators as well as producers and consumers.

The only way in which there can be producers as well as consumers of all kinds of goods is by the maintenance of the great process of economic interaction called *exchange*; and the process of exchange with its rudimentary form of barter and its side-lines and ramifications in money, prices, credit, investment, transportation, commerce, marketing, etc., goes on not merely between individuals but between all the units of social organization like hordes, families, tribes, and nations, tending sometimes to accentuate their isolation from one another and sometimes to make clear their interdependence. This intercourse between social units of varying sizes, now greatly intensified by modern transportation and communication, tends to come under political regulation, and forms one of the chief links between economics and politics.

Evolution in Eugenics and Euthenics

Before turning to the evolution of political institu-

tions, we must consider the bearing upon social institutions of that which next after food is the basic necessity for the development of a society—namely, the relations of the sexes, centering round the process of reproduction and the care and rearing of the younger members of each group. Here again the basis is biological, and all that civilization does is secondary—which fact helps to give rise to the statement that "civilization is only a veneer". The great division of labor in the process of reproduction in all the higher animals separates the female as the producer and usually the chief care-taker and the male as the provider. Around the relations of the sexes all sorts of regulations, moral, political, and religious, arise, and it is possible to trace courses of evolutionary development, particularly in the institution of marriage, although here as everywhere else in the social sciences, one must beware of unilinear theories. Some of the chief problems connected with the young are dealt with in eugenics, which as one of the newer developments in civilization, has to do with the production of healthy offspring, and euthenics, which concerns measures taken by society for the welfare of various classes among its members. Euthenic movements include charities, corrections, various restrictions and prohibitions, and preëminently the huge projects grouped together under the name of education. The history of any of these movements may be studied developmentally and outlined in terms of evolution, although here one must be especially careful not to confuse evolution with progress. All eugenic and euthenic measures, like all economic processes, are in modern life likely to be involved in considerations of morals and politics.

Evolution in Ethics

Any treatment of the evolution of morals must use much the same material as would be considered in studying the evolution of economics, eugenics, euthenics, or politics; hence the evolution of morals may here be treated briefly. The principal new point is that the material is considered with reference to the ends, purposes, values, or ideals of individuals or groups. At first these ends are not reflected upon; any procedure which happens to be effective is likely to become habitual for the group, to be prescribed from generation to generation, and thus to become a "folk-way". The collective name for folkways is "mores", from which our word "morals" is derived. As reflection, under the guidance of more and more skilful leaders, comes to criticize blind customs, and some ends come to be socially recognized and approved, the purposes or ideals of a group gradually change until in a general way they come to include most of the standards and norms familiar in modern life. These standards often vary according to the economic or political units within which they are worked out. In proportion as a standard of conduct has political support and tends to be enforced by political agencies, it becomes a law and has legal as well as moral status.

Evolution in Politics

The political development begins very early in the differentiation, within a horde or family, of some individuals as leaders and others as followers. The oldest or strongest or wisest men are likely to be set apart to serve the remainder of the group in the regulation of relations between individuals in the group or between the group

and other groups. It must always be remembered that political development does not take place in a vacuum. Always portions of the environment are involved as dwelling places and sources of the food supply; hence problems of economics are involved with problems of politics from the very beginning.

The basis of political organization appears at first to be kinship. In the rude hordes at the bottom of the social scale leadership is sometimes temporary or occasional, but in more firmly established social organization leadership is usually based on some kinship relation. Intermarriages between families and tribes and the conquest of some groups by other groups makes for the widening of group boundaries and the organization of more and more inclusive units, of the order of tribes or nations. This calls at first for more and more powerful leaders, as the growth of ancient and early modern despotisms shows. But gradually under the influence of other factors there is a differentiation in the machinery of government, with the development not merely of the executive, but also the legislative and judicial branches. Some ancient writers on the subject of politics thought that governments exhibited typical courses of progress or degeneration or both, passing through such forms as monarchy, aristocracy, democracy, tyranny, etc. These might have been called evolutionary series, but even if they represented accurate readings of the ancient data they would be too simple and uniform for the complicated structures of the great modern governments.

Most impressive of the political tendencies at the present time is that toward international coöperation, sometimes reaching all the way to international political

organization, as in the Hague Tribunals and the League of Nations. Whatever may be said locally and temporarily about the particular merits of these organizations, it is clear enough that they conform to that principle of evolutionism which we call aggregation or integration, and thus that, whether immediately successful or not, they illustrate political evolution on its grandest scale. It is obvious that many other forms of international cooperation in economic activities, as well as in the sciences and the arts, often precede or accompany political integrations.

Evolution in Art

Any evolution of art is difficult to trace, unless one keeps in mind the full force of the statement that evolution is not unilinear. Such an evolution where it can be traced is often conditioned by economic, political or religious motives, as much as by any purely æsthetic interest. And it is difficult to correlate any particular characteristic of works of art exclusively with any definite period of time. It has been customary to say, for example, that ancient art was predominantly massive, as is illustrated in the pyramids of Egypt and in ancient temples; but this is largely a mistaken impression, due to the better preservation of those remains of ancient civilization which happened to be massive. Again, it has often been said that primitive art at first attempts to be realistic, displaying the object in as much of its ordinary appearance as the artists are capable of reproducing. This seems to be true of very primitive painting and sculpture, although geometrical forms are also found. Where there are attempts at realism gradually the technique of repre-

sentation improves, until the objects are reproduced with high degrees of literalness and faithfulness. This gives us various "classical periods" in the arts; they are often succeeded by periods in which ornamentation and embellishment are carried to extremes, in a post-classicism which has become separated from its great examples and inspirations. Then, with an understanding of refined technique, but without employing its full resources, the representations become restrained and symbolical, as in the art of the early Middle Ages in Europe. Symbolism tends always to artificiality; but often at such a stage there is a wholesome return to nature and to accurate representation, which sometimes (as in the case of Gothic sculpture) has to be learned all over again, before it is again forgotten. The technique of pictorial representation seems to have reached another culmination in the European Renaissance. The trend in recent painting away from the photographic and toward the significant and the symbolic seems to be quite in keeping with what might be expected. But the field of the arts is so widely diversified that one must beware lest "what might be expected" is leading to the selection of data which support it while other data, equally significant, are disregarded. And it should be remembered that any adequate account of the evolution of art must include the rich and varied history of art in the Orient.

Evolution in History

Somewhat similar remarks may be made concerning "philosophy of history", which is certainly one of the most fascinating, although at the same time most difficult subjects for investigation in this connection. Any philos-

ophy of history is of importance for evolutionism in so far as the attempt is made to discern a trend, or trends, or lack of any trend in human affairs, considered as a whole. Such theories seem to have been rather more common among the older writers than they are at present; our contemporaries are likely to be appalled by the overwhelming amount of data now available and awaiting interpretation. Among the theories now entertained are those of H. G. Wells, in his *Outline of History*, and W. Patten, in his *Grand Strategy of Evolution*, to the effect that history exhibits a series of steps in the attainment of international unity. Other more or less imaginative writers see in our failure to check the encroachments of bacteria or insects indications that humanity itself may succumb to these enemies, in a stupendously tragic illustration of the principle of the survival of the fittest.

There have been a number of theories to the effect that history proceeds in cyclic fashion; the theory recently most conspicuous is that of the German philosopher, Oswald Spengler, in his two volumes on *The Decline of the West*. But while individual and more or less isolated cyclic processes may often be traced, it is easy to see that Spengler has treated the data quite poetically. In all such works one must remember that human history is not like a river, with facts flowing all uniformly in one direction, but like an ocean where countless currents tumble over one another, and where it is difficult if not impossible to make the facts ebb and flow consistently with any forecasts. But it should be noted that even if history must be regarded as cyclic, evolutionism is by no means discredited. We must bear in mind here as no-

where else that evolution does not necessarily mean progress and that evolutionism is not necessarily called upon to justify itself at the bar of any cosmic purpose. Properly speaking, the question whether there is any cosmic purpose lies outside the range of evolutionism, as it certainly does outside the range of the social sciences. But curiously enough religion itself may be regarded as constituting data for both these types of investigation.

Evolution in Religion

Probably the most striking of all the theories of the evolution of culture is that which attempts to trace the development of religion. We shall treat this in somewhat more detail as an illustration of the evolutionist method and interpretation of data. Rightly or wrongly, men have practically always proceeded as if some power or powers outside were concerned or could be involved in the processes of economics, morals, or politics. In the course of the more recent investigations into the culture of primitive and savage peoples large amounts of data have been gathered, and it has been found possible to arrange them in some rather remarkable series suggesting a process of evolution.[1] The arrangement is made to begin with primitive religions because of their simplicity; they are so simple that in their beginnings they seem to be non-reflective, to consist in attitudes and practices rather than ideas and doctrines, and, as some one has put it, to be "danced out" rather than thought out.

The initial stage seems to have been one in which the

[1] For a more extended account of the evolution of religion, see R. W. Sellars, *Religion Coming of Age* (1928), in this series, especially Chapters IV and V.

primitive peoples acted as if the environment or certain parts of it were characterized by attitudes friendly or unfriendly, and were permeated by power. The Melanesians called this power "mana", and from this word "manaism" has come to indicate this first stage, or as Marett calls it, the threshold of religion. We shall perhaps come nearest to the "mana" attitude if we think of the reactions of superstitious persons to objects regarded as "lucky" or "unlucky". We might say that at this stage the power is regarded as *diffused*.

When objects begin to be distinguished as particularly and individually possessing mana, we have a stage which may be described by the word "animatism". This word is used by Marett to indicate the stage of development in which objects are regarded as living but not as possessing the higher personal attributes. Our use of it to indicate *individuated* mana has direct reference not so much to the usage of Marett as to an attempt which ought to be made to fix more precisely the meaning of the term "animism".

Animism

The word "animism" has often been used in different senses. Particular care should be taken not to confuse animism in anthropology with animism studied above in connection with psychology. The two have much in common, particularly when animism in anthropology is identified with what we shall presently come to call spiritism. Between manaism and animatism, on the one hand, and what we here regard as the later spiritism on the other hand there may, however, be said to be an intermediate step which ought to be indicated by a word

reserved for it. To this intermediate step the word "animism" as used in psychology, especially in the view of the relations of mind and body which is called interactionism, applies more closely than the word animism when it is made the equivalent of spiritism. We therefore use the term animism to indicate the stage at which mana or power is regarded as *separable* from an object, or as going out from the object and sooner or later returning to it again. There can be no question that the experience of primitive men with dreams, shadows, echoes, reflections in pools, etc., inevitably suggested the existence of such powers, and made a place in primitive religions not merely for manaism with its diffused power and "animatism" with its individuated mana, but also for animism with its separable mana.

Totemism and Magic

Another characteristic, or several other characteristics, of primitive religions, may most naturally be considered as the next steps in development. The power which was regarded as separable from a given object came to be regarded as also *transferable* from one object to another. This is most evident in totemism, with its assumption of kinship between a given tribe of men and some species of animal or plant, or some river or mountain in the vicinity. Mana or its equivalent was held to pass from the one to the other. The attitude toward power regarded as transferable is also apparent in various "taboos" or restrictions which surround certain persons, places, times, and ceremonies. Taboo is the negative aspect of the sacred; it is the endeavor to avoid too much of the transferable power.

Where power is regarded as transferable, primitive peoples easily come to treat it as *manipulable.* The attempts to manipulate mana give us primitive magic and sacrifice. The explanation of the remarkable paintings of animals found deep within the limestone caves of southern France and northern Spain is probably that the men who painted them perhaps 15,000 years ago thought that by getting control of the pictures they could get control of the real animals in the hunt. This is called "imitative magic" and is widespread in primitive and savage life. Another type of magic proceeds by obtaining control of a fragment of the object or person over whom control is desired, as when a man gains possession of the nail parings, hair clippings, or perhaps the scalp of his enemy. Doubtless the laws of chance made many of these procedures appear to be effective, and the procedures which chanced to seem effective were repeated until they crystallized into customs and rituals. A degenerate form of magic is called fetishism; sometimes a survival of it is seen in the use of charms. A special class of ceremonies was gradually worked out, with a special class of men to attend to them, resulting in the institutions of sacrifice and the specialization of magicians, shamans, or primitive priests.

Sacrifice

In some of the ceremonies, as when the Semitic Arabs partook of their totem animal, the camel, the aim was to acquire power; this is called the communal meal or communal sacrifice. In other ceremonies, the aim was to avert or ward off a power regarded as injurious. This vicarious sacrifice was carried out by selecting an animal,

sometimes a man, as a victim; surrounding the victim with the taboos with respect to the time of offering, place of offering, and sacred vessels, sacred words, etc., used; and then letting the mana descend (as it was believed) upon the victim, instead of upon the tribe. Such vicarious sacrifice is often, and perhaps always, either *votive*, performed as an offering of devotion or thanksgiving to a higher power or powers; or *placatory*, to procure favor; or *piacular*, performed in expiation for some offence against a higher power or god. Examples of the last-named are afforded in the opening scenes of the *Iliad.* When sacrifice is votive, placatory or piacular, it presupposes developments which we must now consider.

Spiritism

Considering again the stage where power is regarded as separable, we saw that a prime example of this was undoubtedly in the experience of dreaming. The only explanation of a dream which primitive men could entertain was that something of the nature of a "double", or soul, of the man asleep went out of his body, performed the acts seen in the dream and then at his awakening returned to the body again. And the irresistible inference is that when the sleep came which knows no waking primitive men assumed that the mana which used to be separable, and go and come, had now become *separated* and gone to lead an independent existence of its own. There seem to be striking indications that they identified the separated power with the breath which had so obviously left the dead body. In Hebrew, Greek, and Latin the various words for breath are akin to the words used for spirit; hence this stage where power is regarded as sep-

arated and independent may best be called *spiritism.* The primitive tribe thus comes to regard itself as surrounded and helped by the spirits of its ancestors.

Under the influence of the minstrels, poets, and myth-makers, stories about the tribal ancestors were elaborated and moulded upon the events in the history of the tribe; one might say that the power which had come to be regarded as separated was now *celebrated* and rendered more than ever concrete and picturesque. This is the great importance of mythology in primitive development. The inevitable tendency was for the stronger tribes to be thought of as presided over by the stronger spirits. The spirits were thought of as themselves subjected to a kind of division of labor, so that they became *departmentalized* to look after various economic, political, or moral interests of their tribesmen. This is about the stage now apparent in the popular religion of China.

Forms of Theism

As the spirits come to have more activity ascribed to them and to be separated further and further from ordinary human limitations, they are regarded as demons, in polydemonism; and as spirits or demons are invested with more dignity and more power with respect to events in nature and society, they come to be regarded as gods, in polytheism. The usages with respect to the gods come to be treasured in priesthoods and ritualistic books, and these, with the stories about the gods, come to be invested with the character of sacred books. Political consolidation of tribes, each of which has its own god, results in *amalgamated* mana or the amalgamation of the gods. Sometimes this process results in henotheism,

where the various gods are all regarded as existing while one, the god of the most powerful or the chosen tribe, is held to be supreme over the others. In most cases the subordinate gods gradually fade into the twilight and, with the progressive unification of political ideas and ideas about nature, the unified conception dawns that there is after all only one God of heaven and earth. This is the stage of monotheism. In ordinary theism the God is regarded as personal and distinct from the physical universe, although present and interfering in it. The Old Testament is often said to exhibit a development or evolution at least from henotheism (in passages where the existence of the gods of the non-Hebraic peoples is not denied) to monotheism, and even in its monotheism to show some advances, in the content of the moral character ascribed to Jehovah. In deism God is regarded as less highly personal and as more remote from the physical universe. In pantheism, which represents a kind of return to a more contentful mana-ism, God and the Universe are held to be identical, but the personal attributes otherwise ascribed to God usually tend then to become vague.

Of present day religions, Hinduism represents a vast complex of polytheism, henotheism, monotheism, and pantheism. The religions of the Hebrews and of the Mohammedans are strictly monotheistic, although traditionally they admit angels and superhuman beings which may be regarded as divine, but not gods. From the point of view of this central doctrine of these religions the traditional Christian religion is criticized for its doctrine of the Trinity and the saints.

Mohammedanism is an example of a religion with a

personal founder; the others of this class which are best known are Taoism and Confucianism in China, Buddhism, originally in India, and Christianity. Each of the personally founded religions has appeared in an earlier racial religion, as a reform movement led by some man reared in the older faith. Either during the man's lifetime or after his death, or at both times, his followers have accorded him peculiar honors. Confucius, at first regarded as a great teacher of ethics and government, after his death was deified. Gautama, the founder of Buddhism, who preached the annihilation of the world through the annihilation of desire, has come to be regarded by one great branch of his followers as one of the incarnate Buddhas or Enlightened Ones, who come at intervals for the salvation of the world. Among the Christians many doctrines of the Person of Christ, different in their wording and precise content, converge upon the ascription of divine honors or divine nature to Jesus. The development of such doctrines throughout a period of religious history is often spoken of as their evolution.

Conclusion

Such a treatment of data as that just indicated in the case of theories of the evolution of religion illustrates both the weakness and the strength of evolutionism as applied to the social sciences. To any one familiar with the data as delivered by anthropology the most obvious weakness is the unilinear arrangement in stages, with its suggestion that development had to proceed in this definite order from manaism to theism. As a matter of fact the stages are nowhere so simply distinguishable;

every known tribe, for instance, which shows any indications of manaism combines this with animism and other allied practices. At every step influences from outside, as in the process of diffusion of cultures, have been at work and have complicated developments which might otherwise have been simple. There is little if any actual evidence for the view that transitions occur from one stage to another, whether taken in the above order or not; and even if one such series could be found and authenticated, this would not mean that developments elsewhere were uniform with it or similar to it. In other words, both the discernment of such stages and their arrangement in series are not so much anthropological as logical. As in the case of biological evolution, it is not so much a matter of evidence as of inference, and here of rather over-formal inference at that.

The artificiality is still more evident when instead of the particular interest of religion we consider the evolution of cultures in general, or of human culture as a whole. Here the unilinear theories more than ever show their weakness. The whole process is, as Goldenweiser says, best represented not by a ladder but by a network.

On the other hand, the strength of evolutionism here appears first when one feels the real need of an ordering concept to aid in the arrangement and study of data of such untold complexity. Strictly speaking, serial arrangement may be sufficient for this, but serial arrangements when economically interpreted always lend strength to evolutionism.

That evolutionism here may be more than a mere concept, and may point to an actual evolution in societies begins to appear when we remember that all theories of

culture are more or less artificially abstracted and isolated from those biological structures which must serve as their basis. Now the biological or social structures, such as families, tribes, etc., seem to afford indications of integrations or differentiations, or both, and to be fairly enough interpretable in terms of evolution. And in so far as the various types of culture conform to such biological or social structures, a cultural evolution seems also evident; certainly, with restrictions such as above noted, something of the sort is hard to deny in the case of political, economic, eugenic, and sometimes euthenic institutions and processes. Even religious development has often conspicuously followed racial lines.

Finally, evolutionism as an interpretation of cultures seems to be clearest when contrasted with its rival theory of creationism. The creationists and sometimes the theistic evolutionists, too, must account for economic, political, ethical, and religious developments by the aid of a God working antecedently to the processes and often outside them. But the evolutionists, here as elsewhere, emphasize inherent rather than intervening causes. Societal development, even if not unilinear, is thus regarded as self-contained, and even if not progressive is regarded as after all consistent.

It may be added that the field of cultural evolutionism bids fair to become in the near future one of the chief battlegrounds between that part of science and that part of religion whose adherents engage in controversies. No opposition in present-day thinking is sharper than that between the supernaturalists who maintain that God has by a series of special revelations and interventions in human affairs moulded the course of history, and the

naturalists who maintain that man has created the gods in his own image. The questions here are so serious, and evolutionism here passes so easily into naturalism that it becomes plain to students of the subject that the new sociological studies, like the new psychological studies, offer much more serious problems for theology than the biological studies of Darwin, Huxley, and their successors ever offered or could have offered. The chief question which evolutionism in biology raised was one of the theological interpretation of the Book of Genesis. But the question which evolutionism as an interpretation of cultures raises is whether the whole of theology is not a refined mythology.

CHAPTER IX

SOME PHILOSOPHIES OF EVOLUTION

The Science and Philosophy of Evolution

In the six preceding chapters we have traced the theories of evolution in the fields of the physical, biological, neuropsychological, and social sciences and have been concerned with the data in each of these somewhat distinct and separated fields. For any adequate interpretation of evolutionism such detailed work is indispensable, but it is after all only a part of the task. Evolutionism must be considered not merely from the side of the separate sciences but from the side of philosophy. The more precise but less popular way to put this would be to say from the side of metaphysics, because metaphysics, in spite of the fact that various other meanings are assigned to the word, is properly a study of the general principles which become apparent in the data of the several sciences. Many scientists who are experts in their special fields scoff at the word metaphysics, but they are usually taking it to mean some purely speculative work unsupported by experimental evidence, rather than an account of the world in terms of more general principles than their special sciences afford. Properly speaking, evolutionism is a problem not merely for the special sciences, but also for the general science or discipline of metaphysics.

In the history of metaphysical thought, which includes man's attempts to generalize about the world, creationism and kindred views have been developed earlier, have been more widely held, and on the whole have remained more simple than the opposing views of evolutionism. Most of the great religions and the systems of thought which originally and historically have been allied with them have been creationistic. Evolutionism has always been the view of minorities.

Even where a doctrine of evolution has been held, it has been often only within the field of some special science, rather than in the general field of metaphysics. It is often said that evolutionism was held among the Greeks, and it is true enough for example that, as we saw, Anaximander of Miletus about 600 B.C. maintained that man had come from the fish. Traces of evolutionism in biology can be found all the way, as Osborn's title phrases it, "from the Greeks to Darwin".

All this, while significant enough for the history of biology, is not evolutionism in the metaphysical sense. The latter is foreshadowed in several of the great speculative metaphysical systems, such as those of Plotinus and of Hegel. Plotinus lived in the third century A.D., but summed up views which were much older. It is in his work that we find most conspicuously reflected the philosophy of the old Gnostics, that the material world is the result of a succession of "emanations", the first of which came down from or out of a Primal Source and gave rise to the one following it. This in its turn gave rise to a new emanation, and so on, until at length the stage of materiality was reached. The task of man is to make his own way progressively, from the materiality

of the senses up through stages distinguished by reason and contemplation, until again he attains re-absorption in the Highest. According to Hegel (1770-1831), the world as we have it has developed out of a primal condition by repetition, over and over, of a process which may be described as the generation and synthesis of opposites. According to Hegel, any given thing in the course of its development is bound to find itself limited by something which opposes it; but the two opposites may unite in a higher synthesis, thus constituting a new thing, which in turn finds itself limited by its opposite and unites with the latter in a new synthesis. Thus the process goes on, on many different scales and amid successively different circumstances. No matter what portion of the world is studied, one finds always, in the Hegelian language, a *thesis* ("that which is set down") confronted at length by its *antithesis*, and the two together forming a *synthesis*. This cosmic development proceeds from the condition to which only the utterly abstract term "Being" can be applied, through realms of successively more and more concrete realization, until the universe reaches its glorious culmination—politically in the Prussian State, religiously in Christianity, and philosophically in the great Hegelian system itself!

Neither the system of Plotinus nor that of Hegel can be regarded as adequate in this age of empirical science. Each represents an attempt to detect general principles speculatively rather than experimentally, although it must be added that in a world where for instance electrons and protons combine in hydrogen, protein bases and nucleic acids combine in nuclein, and precurrent and consummatory reactions combine in end-reaction complexes, the

Hegelian synthesis of opposites is by no means destitute of all empirical suggestion.

A system much closer to us in this respect is that of the Frenchman August Comte (1798-1857), who deliberately tried to build a philosophy on a "positivist" basis of scientific evidence—the only evidence of which he felt that he could be "positive". He used the notion of development in his famous doctrine that man had passed through three stages, the "theological", or age of faith, the "metaphysical", or (in the sense of this word above noted) the age of unsupported speculation, and the "positivist" stage or stage of dependence upon actual empirical evidence. The history of society, too, was traced through the three stages of militarism, revolution, and positivism; positivism here means essentially the application of intelligence to social problems. If Comte were living today the point last-named would probably leave him with no doubt that evolution is not unidirectional!

Herbert Spencer

A metaphysics of evolutionism in what we may call the modern sense, that is, a metaphysics dominated by the general principle of evolution and, on the whole, built up directly from the data of the various sciences, is first found in the work of Herbert Spencer (1820-1903). This English gentleman lived in the days when under the influence of Lyell it was coming to be recognized that the rocks of the geological record could be best interpreted as the results not of sudden catastrophic changes but principally as the results of long continued gradual changes. At the same time, under the influence of Dar-

win, Wallace, and Huxley, it was coming to be recognized that biology also could be best understood in the light of the same principle. The nebular hypothesis of Laplace, as well as the invention of the spectroscope, had made it appear that nebulæ and stars exhibited gradual developments from one type to another; moreover, the data of psychology and the newly differentiated science of sociology lent themselves readily to similar interpretations. Spencer began with an interest in economics, social sciences, and psychology, but gradually detected in all the mass of data from these and the other sciences the traces of one great process and general principle, that of evolution, and, albeit with some curious and faulty methods, set himself to the task of working out the details. The task occupied him for more than forty years, during which treatise after treatise was produced and published to make up what was called his "Synthetic Philosophy". The completed work included *"First Principles* (1862), *Principles of Biology* (1864-67), *Principles of Psychology* (second edition, 1872), *Principles of Sociology* (1876-1896), and *Principles of Ethics* (1879-1893).

Briefly summarized, Spencer's contentions were that all our experience can be traced to a persistence of force, evident in the resistance which we encounter in objects. "The phenomena of evolution have to be deduced from the Persistence of Force. . . . To this an ultimate analysis brings us down; and on this a rational synthesis must build up. This being the ultimate truth which transcends experience by underlying it, so furnishing a common basis on which the widest generalizations stand, these widest generalizations are to be unified by referring them to this common basis." [1]

[1] H. Spencer, *First Principles,* American edition of 1896, p. 409.

This persistence of force is in a way a guarantee of our knowledge of both matter and mind, although both matter and mind remain ultimately unknowable. Spencer's position here is plain enough, in spite of the ponderous language in which he sums up his views:

"Over and over again it has been shown in various ways, that the deepest truths we can reach, are simply statements of the widest uniformities in our experience of the relations of Matter, Motion, and Force; and that Matter, Motion, and Force are but symbols of the Unknown Reality. A Power of which the nature remains for ever inconceivable, and to which no limits in Time or Space can be imagined, works in us certain effects. These effects have certain likenesses of kind, the most general of which we class together under the names of Matter, Motion, and Force; and between these effects there are likenesses of connection, the most constant of which we class as laws of the highest certainty. Analysis reduces these several kinds of effect to one kind of effect; and these several kinds of uniformity to one kind of uniformity. And the highest achievement of Science is the interpretation of all orders of phenomena, as differently-conditioned manifestations of this one kind of effect, under differently-conditioned modes of this one kind of uniformity. But when Science has done this, it has done nothing more than systematize our experience; and has in no degree extended the limits of our experience. . . . The utmost possibility for us, is an interpretation of the process of things as it presents itself to our limited consciousness; but how this process is related to the actual process we are unable to conceive, much less to know. . . . The interpretation of all phenomena in terms of Matter, Motion, and Force, is nothing more than the

reduction of our complex symbols of thought to the simplest symbols; and when the equation has been brought to its lowest terms the symbols remain symbols still. Hence the reasonings contained in the foregoing pages afford no support to either of the antagonist hypotheses respecting the ultimate nature of things. Their implications are no more materialistic than they are spiritualistic; and no more spiritualistic than they are materialistic. . . . But he who rightly interprets the doctrine contained in this work will see that neither of these terms can be taken as ultimate. He will see that though the relation of subject and object renders necessary to us these antithetical conceptions of Spirit and Matter, the one is no less than the other to be regarded as but a sign of the Unknown Reality which underlies both."[1]

Within the limits thus reserved for the more nearly primary or ultimate questions, the process of evolution goes on. His famous, or infamous, definition is another example of his heavy, difficult style:

"Evolution is an integration of matter and concomitant dissipation of motion; during which the matter passes from an indefinite incoherent homogeneity to a definite, coherent heterogeneity; and during which the retained motion undergoes a parallel transformation."[1]

"Evolution then", he goes on, "under its primary aspect, is a change from a less coherent form to a more coherent form, consequent on the dissipation of motion and integration of matter. This is the universal process through which sensible existences, individually and as a whole, pass during the ascending halves of their histories. This proves to be a character displayed equally in those

[1] *Ibid.*, p. 570ff.

[1] *Ibid.*, p. 407.

earliest changes which the Universe at large is supposed to have undergone, and in those latest changes which we trace in society and the products of social life. Alike during the evolution of the Solar Systems, of a plant, of an organism, of a nation, there is progressive aggregation of the entire mass. . . . It implies a loss of relative motion. At the same time, the parts into which the mass has divided, severally consolidate in like manner. . . . Always more or less of local integration accompanies the general integration." [2]

Matter is, as he says, at first "indefinite, incoherent, and homogeneous"—as might be illustrated by a nebulous cloud of molecules or atoms all of which were chemically of the same kind. But whatever force there is in it persists, and the matter by integration or combination of former units into larger and more complex units becomes more and more "definite, coherent, and heterogeneous". This process may be illustrated by the differentiations in a gaseous nebula which lead to the formation of a cooler star with molecules of different substances in it. The whole process is rhythmic; an evolution such as the foregoing is succeeded at intervals by dissolution. With cumbrous efforts, sometimes pieced out by curious hypotheses, Spencer tried to trace these general principles throughout the data of the sciences as known in his time. The general effect of his philosophy was in the direction of agnosticism and materialism, in spite of the fact that somewhere in his work these extreme positions were relieved by qualifying statements such as those quoted, and any one who looked for it could find that Spencer was ultimately not a materialist, since according

[2] *Ibid.*, p. 337.

to him both matter and mind were aspects of the Unknowable. Even though he was thus ultimately an agnostic, his agnosticism was of the comfortable sort which finds so much of interest and value in the knowable that the outlying marginal region may be neglected and forgotten. But most readers, as well as others who did not read him but were touched by his influence in those days, did not look for these more epistemological and metaphysical points. The result was that Spencer's influence went in on the side of agnosticism, and an agnosticism which tended to make some uncomfortable over the problems of materialism.

Thomas Huxley

The famous biologist Thomas Huxley (1825-1895) had many interests outside the field of his great specialization, and particularly in his *Evolution and Ethics* (1894) developed a view which for a time was of considerable influence in the philosophy of evolution. This was a flat denial that the evolution of the physical world and the lower forms of life was a sanction or inspiration for human morality. "Cosmic evolution", he said, "may teach us how the good and the evil tendencies of man may have come about; but, in itself, it is incompetent to furnish any better reason why what we call good is preferable to what we call evil than we had before. . . . The influence of the cosmic process on the evolution of society is the greater the more rudimentary its civilization. Social progress means a checking of the cosmic process at every step and the substitution for it of another, which may be called the ethical process, the end of which is not the survival of those who may happen to be the fittest, in respect

of the whole of the conditions which obtain, but of those who are ethically the best. . . . The practice of that which is ethically best—what we call goodness or virtue —involves a course of conduct which in all respects is opposed to that which leads to success in the cosmic struggle for existence. In place of ruthless self-assertion it demands self-restraint; in place of thrusting aside, or treading down, all competitors, it requires that the individual shall not merely respect but shall help his fellows; its influence is directed, not so much to the survival of the fittest as to the fitting of as many as possible to survive.

"Let us understand, once for all, that the ethical progress of society depends not on imitating the cosmic process, still less in running away from it, but in combating it." [1]

Ernst Haeckel

The tendency toward materialism was notable in the work of the German biologist and philosopher Ernst Haeckel (1834-1918). In 1899 Haeckel published his famous *Riddle of the Universe.* In this account of the world so far as we can know it, Haeckel reduces everything to matter and force, the persistence of which he indicates in his "law of substance". This fundamental substance, somewhat like Spencer's Unknowable, is supposed to possess properties both of matter and spirit, and the course of evolution in the serial arrangements all the way from atoms to men is marked by "psychic gradations". Haeckel goes further than Spencer in criticisms and strictures upon the traditional theological doctrines

[1] Thomas Huxley, *Evolution and Ethics,* 1899, p. 80ff.

of man's origin and destiny. He is one of the few eminent modern writers who have tried to make belief in life after death absurd and ridiculous.

Haeckel's "platform" may be stated in his own words, formulated in twelve main points. "(1) The universe, or the cosmos, is eternal, infinite, and illimitable. (2) Its substance, with its two attributes (matter and energy) fills infinite space, and is in eternal motion. (3) This motion runs on through infinite time as an unbroken development, with a periodic change from life to death, from evolution to devolution. (4) The innumerable bodies which are scattered about the space-filling æther all obey the same 'law of substance'; while the rotating masses slowly move toward their destruction and dissolution in one part of space others are springing into new life and development in other quarters of the universe. (5) Our sun is one of these unnumbered perishable bodies, and our earth is one of the countless transitory planets that encircle them. (6) Our earth has gone through a long process of cooling before water, in liquid form (the first condition of organic life), could settle thereon.

"(7) The ensuing biogenetic process, the slow development and transformation of countless organic forms, must have taken many millions of years—considerably over a hundred. (8) Among the different kinds of animals which arose in the later stages of the biogenetic process on earth the vertebrates have far outstripped all other competitors in the evolutionary race. (9) The most important branch of the vertebrates, the mammals, were developed later (during the Triassic period) from the lower amphibia and the reptilia. (10) The most

perfect and most highly developed branch of the class mammalia is the order of primates, which first put in an appearance, by development from the lowest prochoriata, at the beginning of the Tertiary period—at least three million years ago. (11) The youngest and most perfect twig of the branch primates is man, who sprang from a series of manlike apes toward the end of the Tertiary period. (12) Consequently, the so-called 'history of the world'—that is, the brief period of a few thousand years which measures the duration of civilization—is an evanescently short episode in the long course of organic evolution, just as this, in turn, is merely a small portion of the history of the planetary system; and as our mother-earth is a mere speck in the sunbeam in the illimitable universe, so man himself is but a tiny grain of protoplasm in the perishable framework of organic nature.

"Nothing seems to me better adapted than this magnificent cosmological perspective to give us the proper standard and the broad outlook which we need in the solution of the vast enigmas that surround us. It not only clearly indicates the true place of man in nature, but dissipates the prevalent illusion of man's supreme importance, and the arrogance with which he sets himself apart from the illimitable universe, and exalts himself to the position of its most valuable element." [1]

In the meantime, the theistic side of the evolutionist argument was being upheld by John Fiske (1842-1901) in America. His *Outlines of Cosmic Philosophy* (1874) was mainly a popularization of the Spencerian teachings,

[1] E. Haeckel, *The Riddle of the Universe,* translated by J. McCabe, 1900, p. 13f.

but had a famous contribution to evolutionism in Fiske's theory that mammalian development, especially in the human species, made necessary a lengthening of the period of parental care and hence promoted family life as the matrix out of which morality developed. In his *Through Nature to God* (1899), he interpreted the whole process of evolution as tending to culminate in morality and religion. This work represents a tendency opposite to that of Huxley, and views the evolution of man as "of a piece" with that of the rest of the universe. The tendency becomes more and more pronounced in other philosophies which we now consider. The view now seems to be that whether the universe is to be understood in terms of mind or mechanism it is hardly our place to combat it.

"Creative Evolution": Bergson

In the last years of the nineteenth century and the first of the twentieth, a great French philosopher, interested in working out a theory that our knowledge of the world around us is to be obtained by a kind of direct inner intuition as well as by the more roundabout methods of intelligence and empiricism, approached the problems of evolutionism from this point of view. To Henri Bergson (1859-   ), approaching from this angle, the Spencerian evolutionism seemed an artificial construction rather than a record of the actual and real process which had taken place. Bergson holds that the process of thinking is itself more or less artificial; at least it has been developed in connection with the practical activities of men, as they more or less artificially distinguished separate objects in their environments.

"The history of the evolution of life, incomplete as it yet is, already reveals to us how the intellect has been formed, by an uninterrupted progress, along a line which ascends through the vertebrate series up to man. It shows us in the faculty of understanding an appendage of the faculty of acting, a more and more precise, more and more complex and supple adaptation of the consciousness of living beings to the conditions of existence that are made for them. . . . The human intellect feels at home among inanimate objects, more especially among solids, where our action finds its fulcrum and our industry its tools; our concepts have been formed on the model of solids; our logic is, preëminently, the logic of solids. . . .

"But from this it must also follow that our thought, in its purely logical form, is incapable of presenting the true nature of life, the full meaning of the evolutionary movement. Created by life, in definite circumstances, to act on definite things, how can it embrace life, of which it is only an emanation or an aspect?" [1]

For this deeper problem, we must be able to employ not intellect, but intuition. Intuition gives us more direct contact with the flow of time and with the course of the evolution of life. This is to say that the world process must, so to speak, be *lived in* rather than thought about, and when we live in the process, or live ourselves into it, when we grip it or let it grip us from within, we get a different interpretation of it. In this inner, direct way we are conscious of freedom. We find that life, as appre-

[1] H. Bergson, *Creative Evolution,* translated by A. Mitchell. New York, Henry Holt and Company, 1911, p. ix. This and the following quotations by permission of the publishers.

hended by intuition, is essentially free and mobile, but that matter, as apprehended by the intellect, is essentially inert.

Again, the vital and the physico-chemical are related somewhat as whole and part. "That life", he says, "is a kind of mechanism I cordially agree. But is it the mechanism of parts artificially isolated within the whole of the universe, or is it the mechanism of the real whole? The real whole might well be, we conceive, an indivisible continuity. The systems we cut out within it would, properly speaking, not then be *parts* at all; they would be *partial views* of the whole. . . . Analysis will undoubtedly resolve the process of organic creation into an ever-growing number of physico-chemical phenomena, and chemists and physicists will have to do, of course, with nothing but these. But it does not follow that chemistry and physics will ever give us the key to life.

"A very small element of a curve is very near being a straight line. And the smaller it is, the nearer. In the limit, it may be termed a part of the curve or a part of the straight line, as you please, for in each of its points a curve coincides with its tangent. So likewise 'vitality' is tangent, at any and every point, to physical and chemical forces; but such points are, as a fact, only views taken by a mind which imagines stops at various moments of the movement that generates the curve. In reality, life is no more made of physico-chemical elements than a curve is composed of straight lines." [1]

The fact is emphasized that the living organisms of various classes develop along divergent lines and still possess organs, such as eyes, of remarkable similarity.

[1] *Ibid.*, p. 31.

This indicates the operation of an *élan vital* or vital impulse working upon matter; thus Bergson belongs among the vitalists. This *élan vital* among the living organisms, working its way upward against the downward pull of matter, is doing on its small scale what "spirit" (*ésprit*) is doing on the large scale throughout the universe as a whole. Bergson's description of the progress of the life impulse is one of the great poetic passages of contemporary philosophy:

"From our point of view, life appears in its entirety as an immense wave which, starting from a centre, spreads outwards, and which on almost the whole of its circumference is stopped and converted into oscillation: at one single point the obstacle has been forced, the impulsion has passed freely. It is this freedom that the human form registers. Everywhere but in man, consciousness has come to a stand; in man alone it has kept on its way. Man, then, continues the vital movement indefinitely, although he does not draw along with him all that life carries in itself. On other lines of evolution there have travelled other tendencies which life implied and of which, since everything interpenetrates, man has, doubtless, kept something, but of which he has kept only very little. It is as if a vague and formless being, whom we may call, as we will, man or superman, had sought to realize himself, and had succeeded only by abandoning a part of himself on the way. . . .

"The animals, however distant they may be from our species, however hostile to it, have none the less been useful travelling companions, on whom consciousness has unloaded whatever encumbrances it was dragging along, and who have enabled it to rise, in man, to heights

from which it sees an unlimited horizon open again before it.

"It is true that it has not only abandoned cumbersome baggage on the way; it has also had to give up valuable goods. Consciousness, in man, is preëminently intellect. It might have been, it ought, so it seems, to have been also intuition. Intuition and intellect represent two opposite directions of the work of consciousness: intuition goes in the very direction of life, intellect goes in the inverse direction, and thus finds itself naturally in accordance with the movement of matter. A complete and perfect humanity would be that in which these two forms of conscious activity should attain their full development. . . . In the humanity of which we are a part, intuition is, in fact, almost completely sacrificed to intellect. It seems that to conquer matter, and to reconquer its own self, consciousness has had to exhaust the best part of its power. . . . Intuition is there, however, but vague and above all discontinuous. It is a lamp almost extinguished, which only glimmers now and then, for a few moments at most. But it glimmers wherever a vital interest is at stake. On our personality, on our liberty, on the place we occupy in the whole of nature, on our origin and perhaps also on our destiny, it throws a light feeble and vacillating, but which none the less pierces the darkness of the night in which the intellect leaves us. . . .

"With it, we feel ourselves no longer isolated in humanity, humanity no longer seems isolated in the nature that it dominates. As the smallest grain of dust is bound up with our entire solar system, drawn along with it in that undivided movement of descent which is materiality itself, so all organized beings, from the humblest to the

highest, from the first origins of life to the time in which we are, and in all places as in all times, do but evidence a single impulsion, the inverse of the movement of matter, and in itself indivisible. All the living hold together, and all yield to the same tremendous push. The animal takes its stand on the plant, man bestrides animality, and the whole of humanity, in space and in time, is one immense army galloping beside and before and behind each of us in an overwhelming charge able to beat down every resistance and clear the most formidable obstacles, perhaps even death." [1]

The effect of Bergson's philosophy, with its inner way of looking at things and its suggestion (not elaborated in detail) of a spirit operative in the cosmos, has been much more favorable to philosophies of religion than was the older evolutionism of Spencer. But Bergson remains virtually committed to vitalism, which means that his philosophy is open to the criticisms of the extreme evolutionists.

"Emergent Evolution": Lloyd Morgan and Alexander

This consideration brings us to the most conspicuous development in present day philosophies of evolutionism. In contrast to Bergson's vitalism, with its central doctrine of an intervening *élan vital,* there is being worked out in England a philosophy now widely known as "emergent evolutionism". Its chief representatives are C. Lloyd Morgan (1852-) and S. Alexander (1859-).

Lloyd Morgan holds that the appearance of new units in the evolutionary series is not due to the intervention

[1] *Ibid.*, p. 266ff.

of an outside agent, but due rather to a peculiar property of the evolving things, or evolutionary units themselves. The process is continuous in the sense that the earlier units such as atoms give rise to later units such as molecules, but it is also discontinuous in the sense that at any given stage the properties of the units to come later cannot be predicted from the properties of the earlier. There is, one might say, genetic continuity, but at the same time generic discontinuity. New units do appear, but appear in ways that cannot be explained by analyzing the new units into their constituents. Using a term first employed by G. H. Lewes, Lloyd Morgan calls the new properties *emergent.* He is careful to say that this does not mean the emergence in the new and more complex unit of anything which was submerged in the earlier and simpler units; the wetness of water, for example, was not hidden away in the hydrogen and the oxygen. When the properties and qualities of the new units are considered, the course of evolution is seen to be *"jumpy"*. Lovejoy has suggested that a better term than emergent would be "epigenetic".

"Evolution, in the broad sense of the word", says Lloyd Morgan, "is the name we give to the comprehensive plan of sequence in all natural events. But the orderly sequence, historically viewed, appears to present, from time to time, something genuinely new. Under what I here call emergent evolution stress is laid on this incoming of the new. Salient examples are afforded in the advent of life, in the advent of mind, and in the advent of reflective thought. But in the physical world emergence is no less exemplified in the advent of each new kind of atom, and of each new kind of molecule. It is

beyond the wit of man to number the instances of emergence. But if nothing new emerge—if there be only regrouping of preëxisting events *and nothing more*—then there is no emergent evolution.

"The essential feature of a mechanical—or, if it be preferred, a mechanistic—interpretation is that it is in terms of resultant effects only, calculable by algebraic summation. It ignores the something more that must be accepted as emergent. It regards a chemical compound as only a more complex mechanical mixture, without any new kind of relatedness of its constituents. It regards life as a regrouping of physico-chemical events with no new kind of relatedness expressed in an integration which seems, on the evidence, to make a new departure in the passage of natural events." [1]

The three "levels", matter, life, and mind, are in relations which Lloyd Morgan calls "involution" and "dependence". "Involves" may be said to mean "cannot exist without"; in this sense mind involves life. The statement "A depends upon B" might be translated "After the emergence of B, A is essentially modified by B"; in this sense life depends upon mind. Lloyd Morgan points out that we are directly aware of the relations of involution and dependence as between mind and life; we extend the relation called involution downwards, so to speak, to include matter, of which we are not so directly aware. But if we are willing to make the extension downwards, it is equally legitimate to extend the relation in the other direction, and to say that matter, life, and mind all together depend in a unified way upon God.

[1] C. L. Morgan, *Emergent Evolution,* 1923, pp. 1, 2, 8.

"I accept under acknowledgment a physical world existent in its own right quite independently of any human or sub-human mind. . . . I admit that in accepting it I go beyond the positive evidence. But I claim that it embodies nothing that is discrepant with, or contradictory to that evidence. How, then, do I reach this acknowledged physical world? By following downwards the line of "involution" till I reach what is, for my constructive philosophy, the limiting concept. But if, in like manner, I follow upwards the line of "dependence", I again reach (for my constructive philosophy) a limiting concept—that of ultimate dependence in terms of which the whole course of emergent evolution is explained (not merely interpreted) within one consistent and balanced scheme. This, too, I accept under acknowledgment. It too lies, as I think, beyond proof by the positive evidence that philosophical criticism demands and, within its province, is right in demanding. But is it discrepant with, or contradictory to, any positive evidence that we are bound to accept with natural piety? I think not. I feel therefore free to urge its legitimacy under acknowledgment. This, for me, leads upward towards God, as directive Activity within a scheme which aims at constructive consistency." [1]

Thus Lloyd Morgan's work points in the direction of a philosophy of religion not unlike that of Spinoza, although God is conceived not so much in terms of a substance and its attributes as in terms of a great process or group of processes. Lloyd Morgan holds that there is a *Nisus* (from the Latin word for striving) in the universe, which accounts for the process of evolution as the latter is evident in the data. The Nisus corresponds not so

[1] *Ibid.*, p. 33.

much to Bergson's *élan vital* as to Bergson's *ésprit*. It is the vast cosmic tendency whereby life in all its manifold variety has succeeded matter, and mind in all its still more manifold variety has succeeded the merely physiological structures and processes which we may group under the term "life".

The system of Alexander is in many respects similar to that of Lloyd Morgan; the two exhibit perhaps the most widespread agreements of any two major philosophers of our day. Alexander's work, incorporated in his *Space, Time, and Deity* (1920), differs in the number of the principal levels or realms into which the cosmos is naturally divided. Instead of treating these as three—matter, life, and mind,—Alexander discusses six with a possible seventh—space-time, primary qualities, matter, secondary qualities, life, mind, and possibly deity. Alexander's doctrine of Space-Time and its properties as a realm underlying and antedating matter and everything else is highly speculative; still it must be said that at least in general the treatment is in line with some of the most striking developments of mathematical physics.

His introduction of levels called "primary qualities" and "secondary qualities" is also speculative and puzzling; it has its roots in certain historical discussions of problems of knowledge. The terms were coined by John Locke, who held that primary qualities, which he enumerated as solidity, extension, figure, and rest or motion, existed in objects independent of our minds—that is, in objects whether our minds experienced these objects or not,—and that secondary qualities, for example, color, are conferred upon objects by our minds experiencing them. Such problems have been very prominent in phil-

osophy—perhaps too prominent—for the past three hundred years, and Alexander has incorporated them into his great metaphysical system.

He holds that each of the six levels after the first is related to the preceding as mind is related to body. This does not mean that each of these levels endows its predecessor with consciousness; the word "mind" must be taken in a broader meaning. We must not suppose that the levels below us are minded as we are; on the other hand, we need not at all suppose that mind in us completes the evolution of the cosmos. The cosmos itself in its Nisus gives indications of something else; it is "pregnant" with a new "level" which may characterize the future. It will be as much superior to our present minds as our minds are superior to our bodies. Alexander calls it "deity". Strictly speaking, it does not yet exist, and yet everything foretokens it and promises it.

In Alexander's own words, "qualities form a hierarchy, the quality of each level of existence being identical with a certain complexity or collocation of elements on the next lower level. The quality performs to its equivalent lower existence the office which mind performs to its neural basis. Mind and body do but exemplify, therefore, a relation which holds universally. Accordingly, time is the mind of space and any quality the mind of its body; or to speak more accurately, mind and any other quality are the different distinctive complexities of Time which exist as qualities. As existents within Space-Time, minds enter into various relations of a perfectly general character with other things and with one another. These account for the familiar features of mental life: knowing, freedom, values, and the like. In the hierarchy

of qualities the next higher quality to the highest attained is deity. God is the whole universe engaged in process toward the emergence of this new quality, and religion is the sentiment in us that we are drawn toward him, and caught in the movement of the world to a higher level of existence." [1]

"Cosmic Evolution": Boodin

Two other current interpretations of evolutionism point toward the view that the cosmos is a great Mind, but offer some variations when compared with the emergent evolutionism just mentioned. A view elaborated on the one hand with more attention to the detail of the physical sciences, and on the other hand with a more poetic formulation and expression, is found in J. E. Boodin's *Cosmic Evolution.* In particular, Boodin thinks that the various emergent theories taken by themselves are not adequate to explain the evolution of life and mind in the earth, but that we must suppose influences of some kind from outside the earth working upon life here and prompting or stimulating it to higher and higher stages.

"In the creative adaptation of the stream of life to the energy patterns of the cosmic environment we have the efficient cause of the evolutionary process. Evolution is indeed to be understood as creative synthesis, as productive reorganization, but it cannot be understood as a synthesis of chance or as a reorganization independent of the environment with which life must effect energy exchange. It is a creative synthesis for which all the necessary conditions are supplied. It must account for

[1] S. Alexander, *Space, Time, and Deity,* 1920, Vol. II, p. 428f.

the emergence and organization of characters; and must not merely make them emerge by magic from simpler antecedents. It must furnish a cause which is adequate to the effect. It is not by chance that life emerged in geological history, nor is it by chance that the series of life forms have emerged. Life is a creative adaptation of the energies of matter under certain conditions—themselves the results of cosmic adaptation—to the energy structure of the cosmos. And new organic characters and changes in form are the progressive differentiations of living matter through a process of creative trial and error adaptation to respond to the energy patterns of the cosmos.

"The cosmic environment acts upon matter, or, better, the cosmic whole stimulates the part, for the earth and the parts of the earth develop in the womb of the cosmos, and under its control. Under favorable qualitative and quantitative conditions the specific stimulus pattern from without overcomes the inertia of the particular structure of matter and starts a process of adaptive response from within the system to meet the action from without. It is thus that new characters and new organs and new life forms emerge. . . .

"Nothing happens by chance, and it is not by chance that organisms have developed eyes, ears and other sense organs. Our senses are creative adaptations to specific energy patterns of the cosmic environment. If these energy patterns had not preëxisted in the cosmic environment and acted upon the organic matter, there would have been no impulse to develop organs of response. . . .

"The levels of life and mind and higher levels are not mere pensioners of the lower material levels. They exist

eternally in their own right in the cosmos and they exercise control over the lower levels. . . . They are the *natura naturans* or creative nature, with reference to the *natura naturata*, the advance already made. . . . This makes the distinction relative in the creative advance of nature, created nature indicating the advance already made, creative nature the advance to be made, but past and future in any one history are both relative to the law of the whole, the creative pattern of the cosmos, the genius of God. . . .

"Broadly speaking, and with due allowance for the limitation of our insight, we may conceive of the genius of God as bearing the same relation to the hierarchy of levels as our mind bears to the levels of human nature. As the human organism is instinct with soul and expresses soul, so nature in its wholeness is instinct with God and expresses God." [1]

"Holism and Evolution": Smuts

J. C. Smuts, the South African statesman well known in international politics, in a book called *Holism and Evolution* (1926), points to the tendency in nature to form units such as we have described, *i.e.*, atoms, cells, etc.; regards such units as wholes; and, coining a word from the Greek to describe the process by which they are formed, makes "holism" a metaphysical principle which affords the key to an understanding of evolution. Smuts appears to be working toward the view that the ultimate instance of holism, or the universe taken in its

[1] J. E. Boodin, *Cosmic Evolution*, 1925, pp. 72f, 266ff.

An idealistic interpretation and criticism of evolutionism may be found in A. E. Taylor's chapter in the collective work, *Evolution in the Light of Modern Knowledge*, London, 1925, especially p. 450f.

totality, must be regarded as mental or personal or spiritual, and perhaps as all three. Toward the end of his book he sums up in these words: "Holism has been our theme—Holism as an operative factor in the universe, the basic concept and action of which can be more or less definitely formulated. I have in the broadest outline sketched the progress of Holism from its simple mechanical inorganic beginnings to its culmination in the human Personality. All through we have seen it at work as the fundamental, synthetic, ordering, organizing, regulating activity in the universe, operating according to categories which, while essentially the same everywhere, assume ever more closely unified and synthetic forms in the progressive course of its operation. Appearing at first as the chemical affinities, attractions and repulsions, and selective groupings which lie at the base of all material aggregations, it has accounted for the constitution of the atom, and for the structural organizing of atoms and molecules in the organization of matter. Next, after some gaps which are being energetically explored by biology and bio-chemistry, and still operating as a fundamental synthetic selective activity, it has emerged on a much higher level of organization in the cell of life, and has again been responsible for the ordered grouping of cells in the life-structures of organisms, both of the plant and animal type, and in the progressive complexifying of these structures in the course of organic Evolution. . . . Next, in the higher animals and especially in man, Holism has emerged in the new mutation or series of mutations of Mind, in which its synthetic coördinating activity has risen to an unheard-of level, has turned in upon itself and become experience, and has achieved virtual inde-

pendence in the form of consciousness. Finally, it has organized all its previous structures, including mind, in a supreme structural unity in Human Personality, which has assumed a dominating position over all the other structures and strata of existence, and has in a sense become a new center and arbiter of reality. Thus the four great series in reality—matter, life, mind, and Personality—apparently so far removed from each other, are seen to be but steps in the progressive evolution of one and the same fundamental factor, whose pathway is the universe within us and around us. Holism constitutes them all, connects them all, and, so far as explanations are at all possible, explains and accounts for them all. Holism is matter and energy at one stage; it is organism and life at another stage; and it is mind and Personality at its latest stage." [1]

"Evolutionary Naturalism": Sellars

A more naturalistic view is advocated by R. W. Sellars in his *Evolutionary Naturalism* (1922). The process and principle which Smuts calls holism and for which other writers have other names Sellars, in accordance with his earlier work, calls "creative synthesis". It is the tendency of units of one kind in combination to constitute units of a new kind, with more complex constitution and with new qualities due to the new togetherness of the parts. No other principle or tendency is needed to account for evolution. "I think that I reflect the contemporary drift", he says, "when I assert that it is a good methodological principle not to assume a dualism unless there is no help from it. . . . It is just as possible to

[1] J. C. Smuts, *Holism and Evolution*, 1926, p. 319f.

say that a system is more than an external sum of parts, that it is an organization in which the whole exerts a control over the parts, that the resultant is a function of the system.

"If these new tendencies are accepted their implications must be worked out. The implication which I have constantly stressed is the forced admission of levels of causality in nature expressive of organization or creative synthesis. In other words, the empirical data force the thinker to construct categories corresponding to them, categories continuous with the old and yet obviously striking a new note. . . .

"The problem of organized packing is important. There must be creative synthesis in which new properties and capacities arise. And yet this rise of higher levels must rest upon and but carry out the potentialities of the lower levels." [1]

The view of Sellars that creative synthesis is the mainspring of evolution is shared by several American realists, notably, by E. G. Spaulding (*The New Rationalism*, 1918). Spaulding has emphasized the bearing of the principle of creative synthesis, and hence of evolution, upon the problem of free will.[2] Creative synthesis affords a problem critical for the whole metaphysics of evolutionism; consideration of it belongs in our general estimate of the strength and weakness of the evolutionist view, which is the subject of our final chapter.

[1] R. W. Sellars, *Evolutionary Naturalism*, 1922, pp. 298ff, 335.
[2] E. G. Spaulding, *The New Rationalism*, 1918, p. 448f.

CHAPTER X

AN ESTIMATE OF EVOLUTIONISM

After having reviewed the data which in the various sciences have suggested the general principle of evolutionism and the different ways in which the principle has been interpreted, it remains to ask how far the principle is sound and the philosophy based upon it true.

The Problem of Proof

It must be admitted at once that unless one is to be over-dogmatic no finally conclusive answer can be given. It should be said explicitly that there is no proof of evolution, either in biology or anywhere else. But it should be made equally clear that for all thinking which is not dogmatic in the other direction there are reasons for believing in evolutionism which in our opinion outweigh any of the reasons usually advanced against it. And it should be added that for all thinking this side of mediævalism the importance of proof as a logical principle or achievement has steadily declined.

A proof, for logic, is the technically correct conclusion of a valid syllogism. Thus we might say, "All Indians are Americans; this student is an Indian; *therefore*, this student is an American"—and we might call the last statement proved by the two following. But there are two difficulties here, and either one or the other of them

is enough theoretically, if not practically, to dispose of any "proof" which may be offered. The first difficulty is that a syllogism may not be technically correct, according to the rules of syllogisms. This difficulty can at least be located and often overcome after a little practice. The second difficulty is that of finding premises, or propositions leading to a conclusion, upon which every one can agree as valid. The syllogism just used as an example, for instance, is technically correct, but millions of persons living in Asia would never agree that "All Indians are Americans". A technically correct syllogism may easily be constructed out of propositions which are absurd —for example "all cats are dogs; all robins are cats, therefore, etc". The great defect in all so-called "proofs" is that their premises are open to question if any one wishes to question them; or, in rare cases where perhaps they are not open to question, they rest upon other premises or presuppositions which are. So far as "proof" goes, then, on the one side or the other of this or any other question, a discussion may be regarded as open when any two persons care to open it.

General Arguments Against Evolutionism: Supernaturalism

In this chapter we shall not consider the arguments against evolutionism in one or another of the particular sciences; they have been noted in preceding chapters. We are here concerned with evolutionism in general, and in the largest sense; against it there seem to be four chief types of argument.

The first is the general argument of supernaturalism, which amounts to a dualism. It asserts that the Universe

is a two-story or dualistic system, one part or element of which, the supernatural, controls the other, or natural. The supernatural is usually held to be known by divine revelation, while the natural may be known by human reason. The supernatural acts upon the natural as an initiating and intervening cause. Historically the most weighty argument for supernaturalism is that it presents itself backed up by some religious, theological, or ecclesiastical authority. In a secondary way it has also been able to avail itself of the fact that there are certain gaps in the account of the world advanced by its opponents.

Among the minority of thinkers whose views make up "modern" philosophy (since 1600), supernaturalism has been more common than is often supposed. In fact the so-called revolt against mediævalism has been more often a revolt against the alleged authoritative basis of mediæval supernaturalism—the claim made by mediæval thinkers that supernaturalism must be accepted because the Bible or Aristotle or both taught it—than against the mediæval or any other supernaturalism itself. Descartes and many other modern thinkers have worked as hard as any to establish the general position of supernaturalism. At the same time in recent philosophy some rather cogent criticisms of supernaturalism have become evident.

According to these criticisms, he who adopts supernaturalism must at least "live it out" and take its consequences. This most often means a certain mediæval cast of mind; supernaturalism is essentially the faith of the Middle Ages, and along with the mediæval mind goes most often a certain reliance upon the authority of others and a certain detachment from the more advanced

sciences. With supernaturalism, too, most often goes a persistent assumption that certain inner experiences are to be regarded as valid, and for these experiences a more or less hidden and curious intuitional verification is claimed, while against all such claims rise the suspicions fostered by recent psychology.

On the other hand, it must be admitted that the foregoing objections to supernaturalism are not necessarily valid. We have no right to condemn mediævalism just because it is mediæval; certainly no other age has any copyright on its own view of truth as the only possibly valid view. The mediæval mind is detached from the most advanced sciences; but this may mean only that mediævalism is opposed to mechanism and behaviorism, and not at all that the last-named views are authenticated. The philosophy of dualism and supernaturalism can in fact be reached on grounds that cannot be said to be either mediæval or unscientific; this has actually been done by Professor Pratt in his *Matter and Spirit.* The great difficulty with such a philosophy is usually its alliance with vitalistic biology and animistic psychology, but these difficulties must be dealt with on their own grounds.

Nor is supernaturalism necessarily refuted by the charge that it is often allied with intuitionism and mysticism. In the first place, supernaturalism may be held for other reasons, with reliance upon other methods of obtaining knowledge, such as rationalism and pragmatism, or even on an alleged empiricism. But more than this, there is no final proof that the intuitional methods are invalid. The more one concerns oneself with the other methods of obtaining knowledge, the more the conviction deepens that they are fragmentary and that they

may be complementary—that they may be developed and held in fact within a more inclusive attitude toward the world, a kind of larger matrix which embodies the reaction of the personality as a whole to the world as a whole. This is not a matter for proof, because proof, where there is any proof, develops within it; it is not even to be reasoned out, but rather, if anything, to be lived out.

The great argument against supernaturalism is the one first made famous by the churchman and supernaturalist, William of Occam, who died about the year 1349. This is "Occam's razor" (or, as we should perhaps say nowadays, Occam's axe), known in logic as the "law of parsimony", or the "principle of economical explanation". Its effect is simply not to make two reasons grow where one is enough. In a way this admission merely restates the problem and transfers the debate to new grounds, because the question then arises as to which set of reasons, the natural or the supernatural, carries the minimum of presumption or assumption necessary for the understanding of the world. In other words, the views of naturalists and supernaturalists differ as to what constitutes economy. And in favor of the supernaturalist view the general fact must be admitted that in the present state of knowledge it is hard for any one to claim with confidence that the universe is only a one-story affair. It seems sometimes fairly easy to dispose of particular and detailed claims of supernaturalism—for instance, it is comparatively easy to deny that water could have been changed into wine at Cana—but with all this the general claim of supernaturalism remains and is not so easy to refute. Certainly any one who to-day should assert roundly that the

Universe is only one substance, or structure, or "story", unconditioned by any other, would be open to the criticism of being over-bold.

Reductional Theories in Science and Philosophy

A second general argument against evolutionism comes from the fact that our experimental sciences, all comparatively young, have thus far been given predominantly to analysis, and that the development of logic with its techniques for reasoning has followed the sciences in this respect rather than pointed the way to anything more synthetic. Here the whole philosophy of evolutionism to-day finds itself in considerable confusion, with some of the workers who would be counted among its staunchest supporters in the sciences virtually arrayed against it in philosophy.

The confusion arises from the fact that the analyses which the experimental sciences perform, for instance in chemistry, and which the newer logics erect into a technique, are what is called "reductional". They tend, that is, to reduce things to the elements of which they are composed, although whether or not the palpable separation of these elements in space is actually performed is of no consequence for the general view here considered. Now on any purely reductional view, such as is likely to be prevalent among scientists, the words " . . . can be reduced to . . . " are equivalent to " . . . amount(s) to no more than . . . ", so that, for example, if a living organism can be reduced to chemical compounds it is held to amount to no more than chemical compounds and to afford no new type of entity. This argument is used here and there at isolated points in the discussion, but

almost never used in its full strength, because if it were carried to the logical extreme it would reduce psychology to physiology, physiology to physics and chemistry, physics and chemistry to configurations of electrons and radiations and these last to no one knows what infra-physical units. And when the argument is carried to its logical extreme the strange paradox remains that in these reductional theories we think one way, reductionally and abstractly, but all the time actually go on living concretely, in a world where such reductions represent only one way of dealing with our data. But some of the extremists among present-day scientists are the hardest to convince of this, and the very fact that they are so hard to convince is just what may give aid and comfort to the enemies of evolutionism.

The only recourse for evolutionism here apparently lies in a recognition that the universe in some sense refuses to be thus reduced, and that there is at least a difference between its origins and its outcomes, between the abstractions which we trace within it and the concretions which it now presents. And when such differences between origins and outcomes are recognized and insisted upon as real, evolutionism offers one of the best ways of accounting for them; according to evolutionism the universe has proceeded from origins in the simple units to outcomes in the complex by the operation of inherent causes, and one prominent feature of this process is to be detected in the process of integration or creative synthesis.

But the analysts and sponsors of reductional views may insist that "creative synthesis", admitted by some of the evolutionists to be essentially unpredictable and "jumpy",

is at its worst a mystery and at its best only a way of baptizing our ignorance. To this charge the evolutionists might reply with some confidence that at any rate some instances of creative synthesis, like that of the crystal of salt, have to be recognized in the data and that many others, like that of the living cell, may be plausibly inferred—if it were not for the fact that the ground on which such assertions rest has recently been shaken by fresh criticisms from the fundamental science of mathematical physics. These criticisms have affected not so much the notion of creative synthesis as those notions of time and causation which creative synthesis involves. This brings us to the third and fourth of the general arguments against evolutionism.

The Relativity of Time

The third of the general arguments against evolutionism grows out of criticism of the ordinary doctrine of time, and the question in what sense it is true that one portion of the cosmos succeeds another. It is easy to show that all our common everyday notions of time may be open to revisions. If I can see objects a mile away and my dog can see objects only at a hundred yards, then what I now see at a distance of a mile is for my dog in a sense future. This may not at first seem likely to the reader, but the reader is a third person, most probably thinking of himself as seeing all of this within the framework or background of the earth. There may, however, be observers elsewhere to whom the earth itself is future—and so on. The theory of relativity with its railroad trains and elevators bearing moving observers has introduced many curious puzzles of this

kind. Even before the days of the relativity theory, introspective psychology had its notions of "time-span". An act of attention which as regards its order in time we call "present" or describe as "now" may last perhaps for a fraction of a second, perhaps for four or five seconds. This is enough to show that the term "present" is relative, and it is easy to suppose that minds of wide grasp or great concentration might considerably extend its span. What is past or future for one mind might thus be all present for a greater mind, although it might not necessarily follow, as the idealistic philosophers tried to show, that differences of time-span, being mental, indicate the existence of one all-comprehending Universal Mind.

These arguments from physics and psychology apparently show at least that we must not build too strongly upon any of our ideas of time. Order in time seems to be assigned in accordance with one or another *point of view*, or, as it is expressed in geometry, by one or another choice of coördinates. And if our ideas of time are fundamentally open to revisions and alternative arrangements, then our arrangements in temporal series are involved ultimately in some choices of coördinates, and our whole philosophy of evolution as a process in time is open to serious question. There may for example be observers for whom the cave-dwellers are our contemporaries; there may even be observers for whom they are our successors, although the point of view of such observers is distinctly not our own. Thus the course of evolution, as we envisage it, seems from other points of view fairly to turn upon itself.

There are two possible answers from the side of evo-

lutionism. In the first place, we have noted repeatedly that evolutionism proceeds not merely by integration but also by differentiation. A molecule, for instance, may be either a combination of atoms or a rearrangement of material in a planet; a multicellular organism may be either a combination of cells or a rearrangement of germinal and other material in a society. In fact, the molecule and the organism may be both integrations and differentiations at the same time. Since this is the case, it is not necessary to speak of planets as altogether later than molecules or of societies as altogether later than multicellular organisms. The fact is that when the various levels of evolutionary units are arranged in a series, that series is not necessarily in the order of temporal succession. There is a process in time involved, but the steps of evolution do not correlate with it in any unidirectional way.

The second answer of the evolutionists with regard to the problem of time is somewhat different. We have seen that in any evolution, in the usual sense of the term, there is a process of time involved; but that process of time may be merely local, and represent only one trend of affairs, or, as it were, only one current in the ocean of the universe. The evolutionists are now forced to admit all this, but they may rejoin that time, even if merely local is at least local, and if the evolutionary series represents only one current in the ocean of the universe it is at least the current which is bearing us along.

The Problem of Causation

The fourth general argument against evolutionism is rooted in recent criticisms concerning the whole notion

of causation. These go virtually to the root of the question of the adequacy of our scientific knowledge. When we examine the structure of this knowledge we find that, as we said, it is based upon measurements, and measurements depend upon observed coincidences. Observations of coincidences sooner or later require light-waves, and the study of light and other radiant energy brings out the fact that our knowledge of it is, after all, primarily statistical. We cannot tell what one single quantum of light will do; we must, as Eddington puts it, wait until we have a quorum. So it appears that our scientific knowledge at its very foundations is indefinite and loose, based upon selection of certain radiations with accompanying neglect or ignorance of others. And our laws of causation must then carry with them something of this initial defect.

It might be added that just as the newer relativist views of time can be reinforced by the notions of time-span drawn from the older introspectionist psychology, so the newer quantum views of causation can be reinforced by the older critique of causation in the work of David Hume. According to Hume all that we ever actually observe are unvarying sequences of events, and to such sequences we contribute our own idea or inference concerning causation.

On either of these grounds, it appears that perhaps after all the world's events are only superficially or statistically subject to the law of cause and effect, and perhaps therefore all our discussions of initiating and intervening as against inherent causes have been beside the point. Perhaps what appears to us as the orderly sequences of cause and effect in evolution are only a

chance pattern or type of order woven upon some underlying web which we do not comprehend.

Here again the only possible answer seems to be that even if we suppose that cause and effect are merely statistical, still it must be admitted that the structures of our part of the universe do occur or present themselves to us in that way rather than in any other way that we can detect. In other words, evolutionism may have its limitations, but these are problematical, and at least within those rather remote limitations evolutionism presents us with one of the few great unifying or approximately unifying conceptions which the sciences and the philosophies have to offer.

The Consequences of Accepting Evolutionism

Let us now ask, if one adopts or accepts evolutionism, what are the consequences? For one thing, the acceptance of evolutionism means at least a long step forward in the progressive unification of one's thinking. This is not attained all at once; the range of evolutionism is so vast that even some of the greatest evolutionists in their views of the world have never attained more than a mosaic of isolated segments. But the acceptance of evolutionism marks at least a long step in this direction. The world begins to appear as something other than a patchwork or as an accumulation of piece-work.

This progressive unification may be in the direction either of the doctrine that the ultimate characteristics of the cosmos are physical and chemical or that they are mental or personal or spiritual; this is a stupendous problem for metaphysics, but it is not the problem of evolutionism. So far as evolutionism goes the cosmos may

be either material, mechanical, mental, spiritual, or a combination of any or all of these. Neither naturalists nor idealists have any lien upon the principle of evolution.

Evolution, Theology, and Religion

It is difficult to indicate with any definiteness the consequences of evolutionism for religion and theology, because any one of these terms may take so many different meanings. The one statement which seems most inevitable is that the acceptance of evolutionism cannot be reconciled with the view that the Book of Genesis has any authority as a treatise on natural science. If this works any danger to one's theology, however, it may in the long run work just as much benefit for his religion; it frees the Book of Genesis and with it other portions of the Old Testament, from entanglements in the machinery of science, and releases it into the sphere of literature, philosophy, and those larger estimates which are things of the spirit.

The issue concerning the origin of the world was touched upon in an earlier chapter; but the issue as raised there was not specifically Christian, because that doctrine of creation was taken over from the older Hebraism in the midst of which Christianity originated. The more specifically Christian doctrine of the origin of the world, although this also was developed from non-Christian sources, is found in the first chapter of the Fourth Gospel. The Fourth Gospel, or Gospel of John, like the Book of Genesis, opens with the words "In the beginning", and presents an account of the origin of the world; the Gospel account, although in some translations it employs the terms of creationism, is more open to

evolutionist interpretations. Behind it evidently is the old Gnostic philosophy of some of the ancient cults, according to which the world originates by a succession of "emanations", or, as we might say, expressions, or radiations, from God, Who is the primary Source of everything. The first expression, or radiation, according to the Gospel, is "The Word" (Logos), which we may understand as a kind of reasonableness or intelligibility in things. It is that quality in the Universe which makes us able to understand it and talk about it. But it is not merely a formal quality; there is also something dynamic about it. According to the Gospel in the King James version, "all things were *made*" by this Word; but in the original Greek the root idea is rather that all things *become*, or "came into being through" the Word. Further on, in the translation, it is said that "the Word was made flesh", where again the word which may be translated "became" occurs in the original. In other words, the Gospel account can be read in terms of a cosmic tendency, the Word, or Logos, or Reasonableness, working through the developing Universe and even becoming incarnate in Jesus.

With regard to the Christian doctrine of the Incarnation, it is often maintained that evolutionism is hostile to it, for two reasons—first, because evolutionism would deny the doctrines of the Immaculate Conception and Virgin Birth, and second, because evolutionism would deny that Jesus, coming in the first century period which is now rather far back in the world's development, could have been sinless, or morally perfect. But a more adequate understanding of evolutionism would place both these assertions in a different light. It is quite true that

there is no support in scientific biology for a doctrine of an Immaculate Conception or Virgin Birth; the attempts to substantiate such doctrines by appeal to parthenogenesis and similar processes turn out to be either grotesque or monstrous. It is equally true that a scientific biology, in one sense, *need* not deny such theological doctrines; appeal may always be made beyond science to the two-story world, with the statement that science deals only with the natural, leaving to religion or theology the supernatural. It may even be said that science deals only with the usual but not with the unique, and that the circumstances attending the birth of Jesus belong to the latter. Here again the chief foe of the theological doctrine is not biology as such and not evolutionism as such, but the naturalism which often coincides with either or both and is confused with them. From still another point of view, the story of the Virgin Birth is quite compatible with evolutionism; this is the view which, finding such stories of the births of founders of religions in Zoroastrianism, Taoism, Confucianism, and Buddhism, as well as in Christianity, regards them all as poetry marking a certain stage in the evolution of literature and art among men.

We said that the other objection to evolutionism was on the basis of the doctrine of the sinlessness of Jesus. If this doctrine is held with a tinge of finality about it, there is something to the objection. Just as evolutionism is at a loss to account for primary beginnings, it is also at a loss to describe ultimate endings. Nothing in evolutionism furnishes a definition of sinlessness, if it is required of such a definition that it set the limits to the development of human character. What evolutionism

might do is accommodate the valuations according to which some human character, either that of Jesus or some other man, might be regarded as the best thus far. And since evolutionism, properly regarded, is by no means unilinear, and proceeds by differentiation as well as integration, it would not matter whether the character called best was developed in the twentieth century, or the first, or any other.

According to most naturalists, all such ascriptions of divine honors or moral perfection are fanciful. As we saw in our sketch of the evolution of religions, naturalism, when taken in this extreme form, traces the development of the idea of God itself to the operation of causes in the human mind and in social experience. This extreme view is imaginative or æsthetic naturalism; according to it, men have created God in their own image and, in the striking words of Santayana, "Jehovah, who would brook no other gods, was himself a myth". According to a less extreme view, allied with what is generally referred to as "theistic evolutionism", the various stages of development as pictured, whether they succeeded one another in just that order or not, represent so many stages in God's progressive revelation of himself to mankind. It is hard to say whether this less extreme view appeals to an inherent cause or an initiating and intervening cause. There is a certain inherence if God is pictured as in the whole process stage by stage, but the appeal is usually more clearly in the direction of a God outside the process and imparting Himself to it by successive interventions. The doctrine of "theistic evolution", to the effect that God starts the process of evolution and uses it as a means of revelation, is, as the name really implies,

a combination of two views. As we have said, the two are not antagonistic unless one understands evolutionism in terms of naturalism.

The world is far enough advanced so that no observing man need for a moment think that an acceptance of evolutionism destroys one's religion. The large and influential group of theistic evolutionists, Christian and non-Christian, makes this contention absurd.

Evolutionism and Theism

There are a number of ways of reconciling evolutionism with theism, or belief in a personal God. Some of these we have noted in preceding chapters. One may, for example, say that God began the whole process of evolution; let us repeat once more that evolutionism as such is not concerned with problems of beginnings. Or, one may say (as in effect was once held long ago in the history of Christian doctrine) that God, although He did not begin the process, will gain control of it and bring it all to a good end. Or, one may say that God is in the process of evolution; this view has an advantage over the more extreme view of pantheism, which holds that God and the universe are identical, since if God is merely in the evolutionary process, evil may still be regarded as foreign to God. The disadvantage for many here is that God is thereby limited and rendered finite; on the other hand it may be urged that any notion of infinity soon becomes unmanageable, and in the long run is perhaps as much of a liability as an asset.

As another possibility, one may recall the view of Alexander, according to whom deity is developing out of the universe as a new level in the process of evolution;

if this view seems too fantastic, it may be modified in various ways. One may, for example, say that the universe, starting with the blind physical processes, is gradually working out those more intricate and subtle structures which we call minds in societies—the structures which are personal and social and ideal, and that, after all, the true object of religious worship is not a God apart from the evolving universe, but, as Alexander and others variously suggest, a God within it, some portion or portions or process or tendency within the universe itself. But, such an argument might continue, if we are ever to find that portion or process, we must find it from within the personal and social structures which condition us and which, in a word, we are. We seem in fact to be in part products and in part producers in a vast personal and social process which as it stretches through history can be called a civilization; and each civilization seems to be characterized and dominated, if not actually then potentially, by one or another of the world's great religions. So if we from our standpoint within the world of persons and societies are to attain any adjustment to the great universe as the object of religion, such an adjustment will be conditioned by one or another of the world's great religions. The way to the object of religion, according to such a view, lies through and from the midst of the great religious movements, with their personal founders and followers, their personal and social achievements and ideals. One might say that this is what is meant by revelation—that the universe is revealed, so to speak, in its personal aspect within the great religions, and that there such personal things must be personally discerned. It may be noted, too, that such discernment may involve not merely reflexes or patterns such as are familiar in

perceptions or language reactions or ideas, but may involve a higher synthesis of such elements in sentiments or values or ideals. Another point which may possibly help in such discernment is that the term "person" may be broadened to include persons of at least one different kind or order than we. Each of us might be called an "individuate person", but at the same time "corporate persons", like a university or a railroad company, are recognized in law. Corporate persons include individuate persons, but perhaps are higher syntheses of such individuate persons. If the meaning of the term "person" could be still further extended to another still more inclusive synthesis of natural and social structures, including individuate and corporate persons and culminating in them, so that the more inclusive synthesis could be called a "culminate person", it might not be so difficult to argue for a doctrine of the Person of God.

On the other hand, all such views are open to criticisms by empiricists and naturalists because they must to a certain extent be built upon hypotheses and because they involve speculations about the universe and our place in it. The empiricists and naturalists find it more consistent with their principles to regard theism as so much imaginative poetry, hallowed because it comes to us as a heritage from vast numbers of the human race and in many respects precious because of the beauty of its imaginative conceptions, but not to be regarded as an authentic description of the real world.

The Future of Religion

Comparisons between present-day religions, particularly in the light of studies of their actual contacts and conflicts, often lead to forecasts concerning their future,

and the whole question is one of picturesque, even if somewhat remote interest. Of course for creationism and allied views the future is in the hands or the mind of God, and is usually awaited in accordance with the teachings of one or another of the "orthodox" theologies, without due regard to the merits of those which differ from the one chosen or inherited by the group concerned. For evolutionists the future of religion is variously interpreted. Some see in the increasing trends toward naturalism only the evaporation of traditional theologies, and along with it the evaporation of religion. The æsthetic naturalists assign to the doctrines of theology an æsthetic function, somewhat like that of the stories of the gods in the Homeric poems. The theistic evolutionists and others look for more and more pruning and refinement of the theological doctrines at the hands of science, but expect a certain more or less considerable residue of meaning to persist and be reinterpreted. In general, the evolutionists expect the principle of the survival of the fittest to obtain between religions as between organisms; and no evolutionist would be surprised to see the principle of aggregation result in a federation of the world religions, or the principle of integration, at some far-off time when all peoples understand one another better, result in a synthesis.

The Future of Evolution

Attempts have sometimes been made by scientists and philosophers of eminence to forecast the future of evolution. In the very nature of the case these attempts are all precarious, and many of them are not worth considering. Futures are not so easily discerned; it is their nature

to be uncertain. But among those men who seem to be best qualified to judge there seems to be rather general agreement that future developments in the evolution of the human race may not consist in marked organic or even mental changes. It is held that the animal body and the human brain alike have reached about the limits of their possible development. It seems likely that future developments will be most conspicuous along social lines. There will doubtless be increasingly complex social organizations as indicated, for instance, in the tendency in the United States for the population to become predominantly urban. There will doubtless also be more and more international organization along economic, cultural, and scientific, if not along political lines. It may be expected, too, that more and more careful sociological studies when understood and acted upon will result in highly increased efficiency of "social engineering", and that eugenic and euthenic measures together will considerably prolong and greatly enrich the average human life. What is needed for human evolutionary advance now seems to be not so much the emergence of new physical or mental qualities, but the more intelligent social use of those qualities and capacities which we have.

It must be admitted that the view that the future of evolution is to be predominantly social, however plausible it is, disregards the possibility that out of the mental development which we know some selected elements might be synthesized or might combine into some new super-mental unit or entity, which, especally in view of our ignorance concerning it, might be called a spirit, or a soul. No one can say either that this will happen or will not happen, but, with eleven billion nerve-cells in the adult

human nervous system to draw upon, the possibility can hardly be denied. A behavioristic psychology may deny the possibility, but is then hardly entitled to employ the principle of creative synthesis elsewhere.

Again, supposing that future development is to be pre-eminently social, there is no guarantee that the ultimate social development will be of the type known here in the earth. When we deal with future possibilities, there must be room somewhere to consider even the fantastic possibilities. Let us suppose, for instance and for the sake of the argument, that the human race should achieve communication with some inhabitants of other planets. The fact that all this is fantastic does not mean that it is impossible; and who can describe what the consequences would be if such a possibility were realized?

General Conclusion

It is in connection with such questions that the great fact becomes clear that evolutionism offers us all a great adventure, or rather a multitude of adventures in thinking, in planning, in coöperating, in living. But there is no need to suppose that it is an adventure at random. Here the evolutionism of Bergson seems to be at fault, in that it takes for granted that the future, just because it is now unpredictable and indefinite, must necessarily be different from the past, and must exhibit the cosmos wandering afield in a blind urge to get away from what it has been. The process of evolution, with all its indefiniteness and contingency, may still, at least in its larger outlines, present us with a series of structures and processes which are related in orderly fashion and which present themselves to us as a pattern with a key to it.

Whether in a large sense the key to it is in human personality, or in some mathematical or logical formula, or in all these, each in its own way, constitutes one of the vast problems of metaphysics. With reference to such problems, evolutionism does little more than to indicate some of the possible relations between various portions of the data. It is, as we have seen, open to many criticisms, some superficial and some profound. There is no proof for it, although there are data which for many minds inevitably suggest it. Its greatest value seems to be that it serves as a correlating principle, even if only a minor one, whereby the data of physics, chemistry, astronomy, geology, biology, psychology, and sociology begin to exhibit more or less orderly relations of structures and processes in time.

INDEX

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	183209